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FUEL ETHANOL AND AGRICULTURE: AN ECONOMIC ASSESSMENT. Office of Energy, U.S. Department of Agriculture. Agricultural Economic Report No. 562.

ABSTRACT

Increased fuel ethanol production from renewable resources like grain through 1995 would raise net farm income benefiting mainly corn and livestock producers. Production of additional byproduct feeds would depress prices of soybeans. Large ethanol subsidies, which are required to sustain the industry, would offset any savings in agricultural commodity programs. Increased ethanol production would also raise consumer expenditures for food. Any benefits of higher income to farmers would be more than offset by increased Government costs and consumer food expenditures. Direct cash payments to corn growers would be more economical than attempting to boost farm income through ethanol subsidies.

KEYWORDS: Fuel ethanol, corn producers, agricultural commodity programs, energy, renewable resources, Federal subsidies, FAPSIM.

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Washington, DC 20250 August 1986

PREFACE

A 1983 joint USDA-Department of Energy report assessed the effects fuel ethanol production has on U.S. agriculture. Subsequently, the General Accounting Office (GAO), in a 1984 report (Importance and Impact of Federal Alcohol Fuel Tax Incentives, GAO/RCED-84-1), suggested that the cost of ethanol subsidies might be offset by reduced costs of agricultural price support programs. The GAO report was not conclusive, however. Since then, representatives of the fuel ethanol industry and some farm organizations have argued in favor of subsidizing ethanol production as a way to raise farm income and reduce total Government costs. These arguments were used during debate on the Food Security Act of 1985 (the Farm Bill). A provision was included in the Act (Section 1024) which permits the Secretary of Agriculture to make accumulated Commodity Credit Corporation (CCC) stocks available, at no cost or reduced cost, to encourage fuel ethanol production.

The question about the tradeoff between ethanol subsidies and agricultural program costs remains unanswered. Uncertainty about the answer has increased with changes in agricultural programs in the Farm Bill and changes that have taken place in the fuel ethanol market. This study was undertaken specifically to address the question.

This study also is a prerequisite to the conduct of a study on the feasibility of a strategic ethanol reserve that is required by Section 1774 of the Food Security Act of 1985.

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SUMMARY

The Nation's alcohol fuels industry was developed in response to concern in the seventies that foreign nations could interrupt our oil supplies and disrupt our economy. Since fuel ethanol from renewable resources like grain and sugar crops can serve as a gasoline extender, major Government efforts were undertaken to stimulate this domestic industry. Since U.S. grain production exceeded demand in recent years, support for the ethanol industry was viewed as addressing two problems: (1) expanding a domestic fuel industry from renewable resources and (2) reducing Government commodity program costs by increasing demand for grain. In 1985, the industry produced some 625 million gallons of ethanol by converting about 240 million bushels of corn and other feedstocks.

This report examines the economics of ethanol production through 1995 and the impacts on farmers, consumers, and Government outlays for ethanol subsidies and agricultural price support programs.

The study used the USDA-ERS Food and Agricultural Policy Simulator Model (FAPSIM) in assessing the interaction of changing ethanol production levels on agricultural and food product demand and prices. The FAPSIM base case had ethanol production increasing from 595 million gallons in crop year 1985 to just over 1 billion gallons per year in crop year 1995. We examined one scenario where ethanol production doubled to 2 billion gallons per year in 1995, and a second scenario where ethanol production declined to zero gallons per year in 1995. These two scenarios were considered extremes which should bracket the most likely outcome.

Among our findings:

- The ethanol industry cannot survive during the period studied without massive Government subsidies, given the outlook for petroleum prices. Costs of producing ethanol in 1986 are estimated to be $1.41-$1.52 per gallon while the wholesale price of gasoline is projected to be $0.55 per gallon, and gasoline blenders value ethanol at $0.20-$0.25 per gallon less than gasoline.

- Unless the Federal subsidies which are scheduled to expire December 31, 1992, are extended, fuel ethanol production likely will be terminated or sharply curtailed after 1992.

- If large enough subsidies are provided, additional ethanol production would increase net farm income by an estimated $2.2 billion over the 1986-94 period, or $0.58 per additional gallon of ethanol. However, a much larger amount (some $1.25-$1.35 per gallon) would go for energy, chemicals, labor, and overhead costs incurred in converting corn to ethanol.

- Subsidies required to sustain the ethanol industry will offset any savings in agricultural commodity programs resulting from the increased demand for corn.

- Corn prices would increase by $0.02-$0.04 per bushel for each 100 million-bushel increase in ethanol-induced demand for corn. However, soybean prices would fall by about $0.04 per bushel and soybean meal prices would fall by $0.12-$0.15 per hundredweight.

- Higher corn prices from additional ethanol-induced demand would increase the cost of producing beef, pork, and poultry. Consumer food expenditures would rise by $8.6 billion, or an average of $2.29 for each additional gallon of ethanol produced.

- When all the costs and benefits are tallied, the Government, taxpayers, and consumers together would lose $6.1-$7.2 billion or $1.61-$1.92 per additional gallon produced during the 1986-94 period if ethanol subsidies were increased enough to prompt the ethanol industry to produce 2 billion gallons in 1995. Conversely, if ethanol production falls to zero, they would save some $6.8-$8.9 billion, or $1.35-$1.76 per gallon not produced.

- Possible improvements in technology through 1995 are unlikely to reduce ethanol production costs enough to significantly alter these conclusions. Nor would the conclusions be altered materially if ethanol producers could get by with existing subsidies.

- Subsidized ethanol production is a very inefficient way to raise farm income. It would be much more economical to burn straight gasoline in our automobiles and pay farmers a direct subsidy equal to the amount they would receive as a result of ethanol production.

Fuel Ethanol and Agriculture:

An Economic Assessment

INTRODUCTION

The fuel ethanol industry has grown from near nothing in 1978 to become an important component of the gasoline market. More than 625 million gallons were produced and blended with some 6 billion gallons of gasoline in 1985. Nearly all U.S. ethanol is produced from corn, so corn producers have come to view ethanol as an important market for their crop.

Many people, including many Members of Congress, believe that increased ethanol production can help solve the problem of overproduction and low prices in agriculture and reduce the costs of Government commodity programs. However, the ethanol industry, like agriculture, is heavily dependent on Government subsidies. As a result, increased ethanol production could simply shift subsidy payments from agriculture to ethanol interests.

Important questions about the feasibility of increasing ethanol subsidies remain unanswered. How much will farmers benefit from additional fuel ethanol production? How much subsidy will ethanol producers need? Will fuel ethanol production raise or lower net Government outlays? This study addresses these questions. It also discusses legislation affecting fuel ethanol and assesses the prospects for fuel ethanol through 1995.

The fuel ethanol industry has its roots in the oil market turbulence of the seventies. At the 35th meeting of the Organization of Petroleum Exporting Countries (OPEC) on September 15, 1973, OPEC ministers demanded renegotiation of a 1971 agreement with the major oil companies. Member nations met on October 8, 1973, for negotiations, but the meetings were unsuccessful. Meanwhile, the Yom Kippur War had erupted along Israel's Egyptian and Syrian borders on October 6 (14).1/

On October 16, the six member nations of the "Gulf" committee of OPEC unilaterally raised the price of Arabian light crude by 70 percent, from $3.01 to $5.12 per barrel (8). On October 17, OPEC ministers agreed on an immediate 5-percent production cut from September levels and threatened additional 5-percent cuts each month until Israel withdrew from Arab territories occupied in June 1967 and restored the rights of Palestinians (14). In addition, a complete embargo on crude oil shipments to the United States was imposed. At that time, the United States relied on Arab sources for 14-18 percent of its

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1/ Underscored numbers in parentheses refer to sources cited in the references.

petroleum supplies, and petroleum furnished at least 50 percent of U.S. energy use (19).

The result was an oil price increase of unprecedented size. In September 1972, the Rotterdam spot price for crude oil was about $3 per barrel and the contract price for Saudi light crude oil was about $2.50. By January 1, 1974, the spot price had soared to $19 and the Saudi contract price had reached $11.65. After a compound annual increase of almost 11 percent from 1970 to 1973, OPEC production dropped 10.5 percent in the last 3 months of 1973 (9).

In March 1974, in response to the embargo and the realization of the potential costs of increasing dependence on foreign sources of energy, the President established the goal of energy independence for the United States by 1980. In connection with this, "Project Independence" was initiated to evaluate the Nation's energy problems and to provide a framework for developing a national energy policy. "Project Independence" examined strategic options available to the United States, including an increased domestic energy supply. In the analysis, fuel alcohol received only passing mention as a part of the broader solar energy component of domestic energy supply.

The embargo officially ended in mid-March 1974. By mid-April, U.S. petroleum supplies had been restored to levels sufficient to eliminate gas lines (13). But the price increase shocked the U.S. and world economies. Concern about reliance on imported oil (table 1) prompted interest in alternative fuels.

Ethanol (ethyl alcohol) was among the renewable domestic energy sources considered. Ethanol can be produced from grain, sugar, whey, and cellulose. Methanol (methyl alcohol) can be produced from wood and other cellulosic materials and coal, but most commercial facilities use natural gas.

Ethanol had several attractions:

- Available technology. Industrial and beverage ethanol industries had perfected the production process. In addition, corn wet-milling facilities can produce either ethanol or high-fructose corn syrup, a sugar substitute.

- Short lead time. A fuel ethanol production facility can start up 11-26 months after construction begins, thereby presenting relatively swift response to the threat of loss of supply of liquid fuels. Other alternate fuels, such as shale oil and gasoline from coal, require far longer periods before economic quantities can be produced.

U.S. ethanol production has grown rapidly since the late seventies. Total production in 1980 was about 25 million gallons (0.48 million barrels) (10). Production was about 625 million gallons (14.9 million barrels) in 1985. Despite recent oil price declines and uncertain prospects for continued ethanol subsidization, alcohol production facilities continue to be planned and built.

Table 1--Domestic petroleum production and imports

Year	Domestic production			Imports		
	Crude oil 1/	Natural gas plant liquids	Total production	Crude oil 2/	Refined 3/ products	Total imports
	Million barrels per day					
1970	9.64	1.66	11.30	1.32	2.10	3.42
1971	9.46	1.69	11.16	1.68	2.25	3.93
1972	9.44	1.74	11.18	2.22	2.53	4.74
1973	9.21	1.74	10.95	3.24	3.01	6.26
1974	8.77	1.69	10.46	3.48	2.64	6.11
1975	8.37	1.63	10.01	4.10	1.95	6.06
1976	8.13	1.60	9.74	5.29	2.03	7.31
1977	8.24	1.62	9.86	6.61	2.19	8.81
1978	8.71	1.57	10.27	6.36	2.01	8.36
1979	8.55	1.58	10.14	6.52	1.94	8.46
1980	8.60	1.57	10.17	5.26	1.65	6.91
1981	8.57	1.61	10.18	4.40	1.60	6.00
1982	8.65	1.55	10.20	3.49	1.63	5.11
1983	8.69	1.56	10.25	3.33	1.72	5.05
1984	8.88	1.63	10.51	3.43	2.01	5.44
1985	8.92	1.62	10.54	3.22	1.83	5.05

1/ Includes lease condensate.
2/ Includes imports for the Strategic Petroleum Reserve which began in 1977.
3/ Includes plant condensate, natural gasoline, unfinished oils, motor gasoline blending components, and aviation gasoline blending components.

Source: (29).

HISTORY AND PRESENT STATUS OF THE FUEL ETHANOL INDUSTRY

The use of alcohol as an automotive fuel dates back to the first modern internal combustion engine, the Otto Cycle (1876), which used alcohol as well as gasoline. Henry Ford designed the Model T (1908) to use alcohol, gasoline, or any mixture of them. During World War II, the United States operated an ethanol plant in Omaha, Nebraska, to produce fuel for the Army, and gas stations in the Midwest sold an alcohol-gasoline blend. Despite this early enthusiasm, alcohol use did not continue to grow, principally because oil was plentiful and inexpensive.

By the seventies, there were virtually no commercial fuel alcohol plants. On July 1, 1979, Amoco Oil Company began marketing an alcohol-blend fuel (12). A nationwide ethanol market survey in early 1980 found fewer than 10 ethanol plants. In mid-1982, there were more than 85 plants and ethanol-enhanced motor fuels had captured more than 1 percent of the total U.S. gasoline market, with sales of more than 100 million gallons per month (11). In 1985, ethanol blend sales accounted for 7.3 percent of total gasoline sales (table 6). Nevertheless, of the 163 commercial ethanol facilities in the United States at the end of 1985, only 74 were operating (45 percent) (10).

Major petroleum companies have become involved in the development of the fuel alcohol industry. Several major oil companies sell ethanol blends and some are involved in ethanol production. Ashland, Beacon, Chevron, and Texaco have built or own shares in ethanol facilities.

In the early eighties, ethanol was marketed as a gasoline extender in response to calls for a domestically derived fuel that would substitute for imported petroleum. Ethanol can be burned in internal combustion engines in its pure form (neat ethanol) or blended with gasoline. Engines designed to burn gasoline require major modifications to burn neat ethanol (which may contain water). Blends containing up to 20 percent anhydrous ethanol (without water) do not require modifications, however. Blends of 10 (volume) percent ethanol and 90 (volume) percent unleaded gasoline were sold as "gasohol," but the term has fallen into disuse by the industry because early problems associated with the fuel, due in part to misblending in some areas, led to consumer resistance. Ethanol blends are now sold as "unleaded with ethanol" or are marketed without any indication of their ethanol content. Many States, however, require gasoline pumps to be labeled to indicate ethanol content.

Ethanol has a much higher octane rating (110-112) than gasoline (87 for regular unleaded), making it a potentially important substitute for lead additives which are being phased out under Environmental Protection Agency regulations. Ethanol has lower carbon monoxide and hydrocarbon emissions than gasoline, but more remains to be learned about ethanol's effects on the environment. Ethanol is water soluble, so extra care must be taken to assure that storage vessels are free of water before alcohol fuels are used.

Each gallon of ethanol contains about two-thirds as much energy (Btu--British thermal units) as does gasoline, resulting in reduced fuel economy. One would expect vehicles using gasohol to show about a 3.3 percent reduction in miles per gallon since ethanol constitutes 10 percent of the ethanol-gasoline blend. In a recent report on the performance of alcohol-gasoline blends, the Department of Energy concluded that gasohol-fueled vehicles averaged 4.7 percent fewer miles per gallon than gasoline-fueled vehicles in automobile fleets (this result was statistically significant). In addition, gasohol-fueled vehicles were found to have significantly more problems, including cranking problems, stalls while starting and in traffic, rough idling, hesitation, and loss of power. Pinging also increased (but not significantly), while dieseling was significantly reduced (18).

In addition to operating difficulties, ethanol fuels have problems of acceptance by the petroleum industry. The larger petroleum companies generally have not embraced ethanol as an octane enhancer, preferring to use their own petroleum-derived enhancers to satisfy octane needs. Ethanol has been used primarily by independent marketers and smaller petroleum companies that have lacked capital to modify their refineries to produce higher octane gasoline.

Some technical difficulties with ethanol also impeded its adoption, including: volatility differences, which favor other octane enhancers; the need for special water-free storage facilities for ethanol and blends; the refusal of most pipelines to carry ethanol fuels because of water contamination problems; difficulty of uniform blending of ethanol with gasoline at some distribution points; variations in State tax exemptions, which discourage ethanol marketing in certain States and cause logistics problems for companies that sell gasoline in different States; the threat of removal of Federal and State subsidies; and pricing problems (unlike other enhancers, which are petrochemicals, the cost of producing ethanol depends largely on corn prices, which are not related to the price of oil) (15).

FEDERAL LEGISLATION

The Solar Energy Research, Development, and Demonstration Act of 1974 (P.L. 93-473) began the legislative support for alternative fuels by authorizing research and development into "the conversion of cellulose and other organic materials (including wastes) to useful energy or fuels."

The Food and Agriculture Act of 1977 (P.L. 95-113) authorized loan guarantees of up to $15 million each for four biomass (ethanol from vegetative material) pilot plants. The financing was to be administered by the Farmers Home Administration with Commodity Credit Corporation funding authority. Two ethanol plants were considered for financing under this program but neither was funded. The law also expanded the general agricultural research authority of USDA to include energy-related research and set up a competitive grant program for energy-related research into substitutes for nonrenewable fuels, petrochemicals, and industrial hydrocarbons.

The Energy Tax Act of 1978 (P.L. 95-618) exempted fuel containing at least 10 (volume) percent alcohol from the $0.04-per-gallon Federal gasoline excise tax through October 1, 1984. The law also granted a 10-percent energy investment tax credit (EITC) for equipment to convert biomass into alcohol using a primary energy source other than oil, natural gas, or their derivatives. This credit was in addition to the standard 10-percent business investment tax credit and was to be effective through December 31, 1982.

The 1979 Interior and Related Agencies Appropriation Act (P.L. 96-126) appropriated $19 billion for an "Energy Security Reserve" to stimulate commercial production of alternative fuels. The law earmarked $100 million from this fund for product development feasibility studies and $100 million for cooperative agreements to support commercial scale development of alternative fuels facilities.

The 1980 Supplemental Appropriation and Recission Act (P.L. 96-304) earmarked an additional $100 million for project development feasibility studies and $200 million for cooperative agreements. The Department of Energy (DOE) made 47 feasibility study grants under these laws totaling $21 million during fiscal 1980 and 1981. DOE also entered into cooperative agreements with three producers involving $36 million (table 2).

The Crude Oil Windfall Profit Tax Act of 1980 (P.L. 96-223) extended the $0.04-per-gallon Federal gasoline excise tax exemption for ethanol blends to December 31, 1992, and extended the EITC through December 31, 1985. An income tax credit also was provided to alcohol fuel blenders: $0.40 per

Table 2--U.S. Department of Energy ethanol financial assistance

Company and location	Loan amount	Rated plant capacity	Status
	Million dollars	Million gallons/year	
Loan guarantees:			
New Energy South Bend, Indiana	127.0	50	Loan obligated October 26, 1982
Tennol Inc. Jasper, Tennessee	65.0	25	Loan obligated August 22, 1984
Agrifuels Refining Corp. New Iberia, Louisiana	78.9	35	Loan obligated September 27, 1985
Circle Energies Corp. Blair, Nebraska	41.0	16.8	Pending
Minnesota Alcohol Producers Mankato, Minnesota	42.0	17.8	Pending
Total	353.9	144.6	
Cooperative agreements:			
Kentucky Agricultural Energy Corp. Franklin, Kentucky	9.8	20	Funded under P.L. 96-126. In bankruptcy.
South Point Ethanol South Point, Ohio	24.5	60	Funded under P.L. 96-126
Columbia Energy Resources Takoma, Washington	1.76	10	Funded under P.L. 96-304. Original agreement totaled $2.7 mil. Contract terminated after disbursement of $1.76 mil.
Total	36.06	90	

Source: Office of Alcohol Fuels, Department of Energy.

gallon for alcohol of at least 190 proof and $0.30 per gallon for alcohol of 150-190 proof. This credit was to be reduced by the amount of any gasoline excise tax exemption claimed.

The Energy Security Act of 1980 (ESA) (P.L. 96-294) contained several provisions benefiting fuel ethanol.

The ESA authorized:

- Insured loans of up to $1 million for small-scale biomass energy programs (less than 1 million gallons per year of ethanol).

- Loan guarantees to cover up to 90 percent of the cost of the construction of biomass energy projects.

- Price guarantees for the products of biomass energy projects.

- Purchase agreements for biomass energy that could be used by Federal agencies.

The ESA required:

- Two reports to be prepared jointly by USDA and DOE proposing national biomass energy production and use plans with specific goals for (1) producing 60,000 barrel equivalents of alcohol per day by yearend 1982 (23) and (2) producing by 1990 an annual volume of alcohol equal to at least 10 percent of annual gasoline consumption in the United States (22).

- The establishment of the Office of Alcohol Fuels in the Department of Energy to administer the provisions of the law relating to DOE.

The ESA authorized the Departments of Agriculture and Energy to spend $600 million each for biomass energy activities. Congress subsequently appropriated (P.L. 96-304) $525 million to each Department. The following year, P.L. 97-12 rescinded $505 million of the USDA funding; $20 million was retained for ESA administrative costs. DOE retained authority to guarantee up to approximately $800 million in alcohol fuel loans (a direct appropriation of $271 million, which could be leveraged up to three to one).

Of the ESA alcohol support provisions, only DOE's loan guarantee program is currently funded. When this program expired on September 30, 1984, loans had been finalized for two plants with a combined annual capacity of 75 million gallons. P.L. 99-24 extended until September 30, 1985, the period for DOE consideration of four other loan guarantee applications under this program. One, for a 35-million-gallon plant, has been granted. Loan guarantee authority was extended until June 30, 1986, by P.L. 99-190. Only two guarantee applications are still pending. DOE has interpreted the law as permitting the extension of its loan guarantee authority through January 31, 1987. If these guarantees are granted, DOE loan guarantees will total $353.9 million for a capacity of 144.6 million gallons per year (table 2).

The ESA amended the Food and Agriculture Act of 1977 (P.L. 95-113) to permit the use of set-aside acreage for energy crop production upon a determination by the Secretary of Agriculture that such production is necessary to provide adequate ethanol feedstocks, is not likely to increase the cost of price-support programs, and will not adversely affect farm income. No action has been taken under this provision.

The Consolidated Farm and Rural Development Act of 1980 (P.L. 96-438) authorized the Farmers Home Administration to guarantee loans for alcohol production facilities under the Business and Industry Loan Program (B&I). The appropriation (P.L. 97-12), which rescinded $505 million under the Energy Security Act, also appropriated $250 million for B&I alcohol loan guarantees. Twelve loan guarantees have been issued; all but three are in various stages of liquidation (table 3). There are three outstanding conditional commitments for FmHA loan guarantees (table 4).

The Agricultural Act of 1980 (P.L. 96-494) established an Alcohol Processor Grain Reserve program whereby small-scale alcohol processors, financed in whole or in part by a Federal funding program, could obtain a loan from the Department of Agriculture on the grain purchased and stored for conversion into alcohol. The loan was to be available only on a determination by the Secretary that alcohol producers could not otherwise obtain a dependable supply of grain at reasonable prices. No action has been taken under this provision.

The Agriculture and Food Act of 1981 (P.L. 97-98) authorized the sale of Government-owned corn below the statutory sales price for use in the production of ethanol, but only at facilities that (1) began operation after January 4, 1980, and (2) can produce alcohol from agricultural or forestry biomass feedstocks other than corn whenever supplies of corn are not readily available. No action has been taken under this provision.

The Energy Emergency Preparedness Act of 1982 (P.L. 97-229) authorized the establishment of a Strategic Alcohol Fuel Reserve (SAFURE) to stockpile alcohol fuel made from Government-owned corn.

The SAFURE has been studied by the Department of Energy (24), the General Accounting Office (33), and the Congressional Budget Office (20). The DOE report concluded that the net economic and security benefits of the Strategic Petroleum Reserve (SPR) are higher and the budget costs lower than those of a SAFURE. The CBO report concluded that a SAFURE would not be a cost-effective supplement to the SPR and that it would result in very high costs for an inconsequential number of new jobs. The GAO study stated that the economics of a SAFURE are questionable. It noted shortcomings in the CBO and DOE analyses and stated that "it would not be appropriate to either accept or reject the SAFURE concept based on the results of these studies." GAO believed that more precise data on the costs of the existing corn program would be needed before a conclusive study could be done.

The Surplus Agricultural Commodities Disposal Act of 1982 (P.L. 97-358) added Section 423 to the Agricultural Act of 1949 granting the Secretary of Agriculture discretionary authority to use surplus Commodity Credit Corporation stocks for conversion into fuel alcohol.

The Surface Transportation Assistance Act of 1982 (P.L. 97-424) increased the Federal gasoline excise tax to $0.09 per gallon and increased the alcohol-

Table 3--Alcohol fuel production loans on which guarantees have been issued by the U.S. Department of Agriculture

Company and location	Loan amount	Plant capacity	Status
	Million dollars	Million gallons/year	
Clinton-Southeast Joint Venture (Georgia)	1.85	3.0	In bankruptcy
Idahol Fuels (Idaho)	.475	.35	In liquidation
Farm Fuel Production (Iowa)	3.8	2.3	In liquidation
Kentucky Agricultural Energy Company (Kentucky)	35.2	21.0	In bankruptcy
American Fuel Technologies (Maryland)	2.5	3.4	Loan repaid
ADC-I, A Nebraska Limited Partnership (Nebraska)	20.0	10.0	
Boucher Rural Products (Nebraska)	.28	.168	In liquidation
Dawn Enterprises (North Dakota)	20.0	10.0	
South Point Ethanol (Ohio)	32.0	60.0	
Carolina Alcohol (South Carolina)	.495	.51	Liquidated, FmHA paid $495,000
Sepco, Inc. (South Dakota)	.5	.8	In liquidation
Coburn Enterprises (South Dakota)	.75	1.0	In liquidation
Total	117.85	112.528	

Source: Business and Industry Program, Farmers Home Administration, June 1986.

Table 4--Alcohol fuel production loans for which conditional commitments have been made by the U.S. Department of Agriculture

Company and location	Loan amount	Plant capacity
	Million dollars	Million gallons/year
Elgin Alcohol Fuels, Inc. (Iowa)	2.6	1.5
High Plains Corporation (Kansas)	20.0	10.0
Alchem, Limited (North Dakota)	8.4	4.0
Total	31.0	15.5

Source: Business & Industry Program, Farmers Home Administration, June 1986.

blended fuel exemption to $0.05 per gallon effective April 1, 1983. The law provided a complete $0.09 exemption for fuel containing at least 85 percent alcohol produced from anything other than petroleum or natural gas. The blender credit was increased to $0.50 per gallon for alcohol of at least 190 proof and to $0.375 per gallon for alcohol of 150-190 proof.

The Tax Reform Act of 1984 (P.L. 98-369) retained the $0.09-per-gallon Federal gasoline excise tax and imposed a $0.15-per-gallon excise tax on diesel fuel. Both gasoline and diesel fuels containing at least 10-percent alcohol were exempted from $0.06 of the excise tax. The law taxed fuels containing at least 85 percent alcohol produced from natural gas at $0.045 per gallon. The blender credit was raised to $0.60 per gallon for alcohol of at least 190 proof and to $0.45 per gallon for alcohol of 150-190 proof. Federal gasoline excise taxes are used to maintain the Nation's roads. Gross losses in Federal excise tax revenue as a result of the exemption for ethanol blends in 1984 were estimated by the Federal Highway Administration at $243 million. The Treasury Department estimates that losses will continue to increase (table 5).

The Food Security Act of 1985 (P.L. 99-198) provided authority for the Secretary of Agriculture to make Government-owned commodities available free or at reduced cost for the production of liquid fuels. A temporary ethanol feedstock assistance program (May 10 to September 30, 1986) was initiated under this authority (see below). The law required the Department of Agriculture to report to Congress by December 23, 1986, on the cost effectiveness, economic benefits, and feasibility of a Strategic Ethanol Reserve with an examination of the implications of such a reserve on both the general and farm economies. The law also required a study of the impacts of Brazilian ethanol imports; that study was submitted to Congress on May 28, 1986.

STATE LEGISLATION

In addition to Federal efforts, 29 States subsidize fuel ethanol sales within their borders in amounts ranging from $0.01 per gallon of gasoline-ethanol blend (Connecticut, Iowa, and Nevada) to $0.16 (Louisiana) (table 6). State subsidies take the form of sales tax exemptions in Indiana and Illinois, producer tax credits in Montana and Utah, and gasoline excise tax exemptions in all other States with subsidies.

State subsidies are volatile and subject to frequent revision. Most State subsidies fall in value from year to year. No State support extends beyond 1992, the year in which the Federal gasoline excise tax exemption expires. State laws vary; some restrict subsidies to alcohol produced within the State or in States with reciprocal agreements.

In most States with subsidies, the State transportation or highway department bears the cost of the program. In California, the cost of the now-expired program was borne by the State's general fund. The total cost of State subsidies in 1985 was $302.5 million (unpublished estimate of the Office of Highway Information Management, Federal Highway Administration). Because the loss of highway funds can have severe implications for maintenance of State roads, some States are considering legislation in which the highway fund would be reimbursed by the general fund. Legislation is pending in some States to reduce or

Table 5--Cost of Federal gasoline excise tax exemption

Year	Gross loss 1/	Net loss 2/	Cumulative net loss
		Million dollars	
1980	20	15	15
1981	29	21	36
1982	80	60	96
1983	202	152	248
1984	271	203	451
1985	438	329	780
1986	456	342	1,122
1987	528	396	1,518
1988 3/	564	423	1,941
1989 3/	600	450	2,391
1990 3/	600	450	2,841
1991 3/	600	450	3,291

1/ Loss to the Highway Trust Fund. No provision to reimburse the fund from the general treasury exists.
2/ Reflects net loss of total Federal revenues including changes in individual and corporate income tax receipts, which increase when excise tax exemption losses increase (assumes constant GNP).
3/ Assumes continuation of Highway Trust Fund, which expires September 30, 1988.

Source: U.S. Department of the Treasury.

eliminate ethanol support programs. Reasoning that they can eliminate State tax exemptions if Federal exemptions are raised, some States have urged the Federal Government to raise the gasoline excise tax exemption above the current $0.06 per gallon.

While a minimum State subsidy generally is needed for ethanol to be offered for sale in a State, the volume of ethanol blend sales within a State does not necessarily reflect State subsidy levels (table 6). Likewise, subsidy levels do not appear to be the sole determinant of whether plants will operate or not. Market penetration also is determined, in part, by the production of ethanol within the State or in a nearby State. For example, in 1985, Alaska had an $0.08-per-gallon State gasoline excise tax exemption, but did not record any sales. Illinois had the highest sales volume in the Nation in 1985 although its tax exemption was only 4 percent of the sales value; Ohio was second with an exemption of only $0.025 per gallon. The highest market penetration in 1985 occurred in Iowa, at 33.7 percent of gasoline sales, despite the fact that the State exemption fell from $0.02 to $0.01 during the year.

Table 6--Net State gasoline tax exemptions and market penetration rates for ethanol/gasoline blends 1/

State	1985 market penetration 2/	State exemption 3/			Ethanol facilities	
		1986	1987	1988	Operating	Nonoperating
	Percent	Cents			Number	
Alabama	11.74	3	3	3	0	1
Alaska	0	8	8	8	0	0
Arizona	0	0	0	0	0	0
Arkansas	1.92	0	0	0	1	1
California	2.24	0	0	0	5	3
Colorado	14.86	5/0	0	0	2	5
Connecticut	1.31	1	1	1	0	0
Delaware	0	0	0	0	0	0
D.C.	4/	0	0	0	0	0
Florida	11.48	2	2	2	0	2
Georgia	4/	0	0	0	0	2
Hawaii	4/	5/	5/	5/	1	0
Idaho	5.05	4/0	0	0	2	5
Illinois	20.37	5/	5/	5/	8	1
Indiana	22.05	5/	15	15	1	2
Iowa	33.67	1	1	1	6	4
Kansas	23.19	4/2	3/2	2	4	0
Kentucky	31.71	3.5/0	0	0	1	3
Louisiana	9.33	16	16	16	4	13
Maine	0	4	3	2	0	0
Maryland	1.82	3/0	0	0	0	1
Massachusetts	0	0	0	0	0	0
Michigan	10.95	0	0	0	0	3
Minnesota	15.57	4	4	4	4	4
Mississippi	0	5/	5/	5/	0	0
Missouri	1.74	0	0	0	0	1
Montana	2.08	6/ 50	6/ 50/30	6/ 30	2	1
Nebraska	31.43	3	3	3	3	2
Nevada	0.17	1	1	1	0	1
New Hampshire	0	0	0	0	0	0
New Jersey	0	8	8	6	1	0
New Mexico	12.29	11	10/8	8/5	4	15
New York	0	0	0	0	0	0
North Carolina	7.65	0	0	0	0	0
North Dakota	13.94	8	8	8/4	2	0

See footnotes at end of table.

Continued--

Table 6--Net State gasoline tax exemptions and market penetration rates for ethanol/gasoline blends--continued

State	1985 market penetration 2/	State exemption 3/ 1986	1987	1988	Ethanol facilities Operating	Nonoperating
	Percent	Cents			Number	
Ohio	14.60	2.5	2.5	2.5	2	0
Oklahoma	1.10	0	0	0	0	2
Oregon	4/	0	0	0	1	1
Pennsylvania	4/	0	0	0	1	1
Rhode Island	0	0	0	0	0	0
South Carolina	4/	6	6	6	1	0
South Dakota	14.91	4	4/3	3	0	3
Tennessee	13.74	4	4	0	2	0
Texas	4.83	7/	7/	0	3	4
Utah	0.80	6/30	6/30	6/30	1	1
Vermont	4/	0	0	0	0	1
Virginia	12.61	8/6	6	6/4	8	2
Washington	.39	2.8	2.8	2.8	2	2
West Virginia	.26	0	0	0	0	0
Wisconsin	.78	0	0	0	2	2
Wyoming	.10	0	0	0	0	0
United States	7.26				74	89

1/ Multiple exemption rates indicate change during year.
2/ Percentage of total gasoline sales represented by alcohol/gasoline blends. Calculated from (2).
3/ Amount exempted from State gasoline excise tax or sales tax for alcohol/gasoline blends.
4/ Less than 0.1 percent.
5/ Exemption calculated as percentage of value of retail gasoline sales.
6/ Montana and Utah provide a producer tax credit ($0.70 and $0.50 per gallon of ethanol, respectively) rather than a tax exemption.
7/ Variable incentive.

Sources: (2, 10, and 12).

ETHANOL IMPORTS

When the Federal gasoline excise tax exemption for ethanol blends began with the Energy Tax Act of 1978, it applied to both domestic and imported ethanol. Imported ethanol had been excluded from the exemption in an early draft of the bill and, following passage of the law, a movement to deny the exemption to imports began anew. Without an import tariff, its proponents argued, ethanol

Table 7--Imports of fuel alcohol

Year	Quantity	Value
	Gallons	Dollars
1981	4,440,177	5,835,913
1982	14,525,577	14,187,524
1983	55,266,869	53,158,828
1984	115,254,884	93,451,208
1985	65,225,939	97,517,477

Source: Bureau of Census, U.S. Department of Commerce.

imports would receive the benefit of the excise tax exemption, resulting in Federal subsidization of foreign ethanol production. Fuel ethanol imports increased from 1981, the first year of substantial imports, through 1984, but fell in 1985 (table 7).

The Crude Oil Windfall Profit Act of 1980 (P.L. 96-223) mandated a study of the means that could be used to limit fuel alcohol imports (31). The Omnibus Reconciliation Act of 1980 (P.L. 96-499) imposed a tariff on imports of fuel alcohol entering the country after January 1, 1981. The tariff, in addition to the 3-percent *ad valorem* tax, was $0.10 per gallon for calendar year 1981, $0.20 per gallon for calendar year 1982, and $0.40 per gallon from 1983 through 1992. The Surface Transportation Assistance Act of 1982 (P.L. 97-424) increased the tariff to $0.50 per gallon and the Tax Reform Act of 1984 (P.L. 98-369) increased it to $0.60 per gallon, levels equal to the Federal gasoline excise tax exemption for ethanol blends.

In the period since the tariff was imposed, world sugar prices have fallen precipitously from the 1980 price of almost $600 per ton to the average 1985 world price of $81 per ton. This equals a sugar feedstock price of about $0.53 per gallon (based on 13 pounds of sugar to 1 gallon of ethanol), compared with a 1985 calendar year average net corn feedstock price of $0.54 per gallon for wet milling (2.5 gallons per bushel) (based on $2.49 corn and $0.46 byproduct credit per gallon).

Dumping and Subsidy Investigations

In February 1985, the domestic fuel ethanol industry filed petitions with the International Trade Administration (ITA) of the Commerce Department and the International Trade Commission (ITC) alleging that Brazil was selling ethanol in the United States that benefited from Brazilian subsidies or was sold at less than fair value (dumped) and that such sales caused material injury or the threat of future material injury to the U.S. ethanol industry.

ITA's investigation covered 1982 to November 1985. The ITA found both dumping and subsidization of Brazilian ethanol and determined countervailing duty and antidumping margins. But the ITC found that Brazilian ethanol sales did not cause material injury or present a threat of material injury. As a result of the finding of no material injury, no additional duties are being imposed on ethanol imports from Brazil to offset the pricing irregularities found by the ITA. Petitioners are appealing the case in the Court of International Trade.

The Department of Agriculture was required by the Food Security Act of 1985 (P.L. 99-198) to conduct a study to determine the impact of imports of Brazilian ethanol on the price of domestic grains and on the domestic ethanol industry. In addition, the report was to determine what relief should be granted because of Brazilian imports. Consistent with the ITC findings, USDA determined that Brazilian ethanol has not affected the U.S. ethanol industry significantly, nor is the domestic industry threatened by future imports from Brazil. Likewise, no significant effect on the prices of corn, soybean meal, or byproduct feeds was found to result from imports of fuel ethanol from Brazil. The study contained a recommendation that no relief be granted in connection with the importation of Brazilian ethanol.

Caribbean Basin Ethanol Imports

Countries under the Caribbean Basin Initiative (CBI) are exempt from the import tariff, making ethanol from such nations economical in the U.S. market. If current sugar prices persist and CBI countries increase their ethanol production capacity, imports could increase.

A number of factors, including a reduction in U.S. sugar import quotas, have stimulated the conversion of sugar to ethanol in sugar-producing countries. Current installed ethanol capacity in CBI beneficiary countries totals about 35 million gallons per year, of which about 15 million gallons are made from local sugar or molasses. The remaining capacity is used to upgrade imported hydrous ethanol to fuel grade (anhydrous). Ethanol imported from CBI countries is exempt from import duties if the ethanol is substantially transformed and 35 percent of its value is added in the CBI. The U.S. Customs Service has ruled that distillation of hydrous ethanol to anhydrous grade fulfills these requirements.

About 13.1 million gallons of ethanol were imported from CBI countries during the first 10 months of 1985, compared with U.S. production of about 625 million gallons in 1985. New ethanol capacity is being planned and built in CBI countries. El Salvador, Costa Rica, and Guatemala are each building 6-million-gallon-per-year facilities that will use native feedstocks. Jamaica currently produces approximately 20 million gallons of ethanol per year by distilling hydrous ethanol, principally from non-CBI countries, and is building another 50-million-gallon-per-year distillation plant.

There has been considerable opposition to the duty-free imports of non-CBI ethanol that has been upgraded in CBI countries. A number of bills have been introduced that would limit duty-free ethanol imports from the CBI. None of these efforts has been enacted. The administration opposes efforts to modify the CBI treatment of ethanol imports because such a change could threaten the objectives of the CBI program.

Customs Investigation

The U.S. Customs Service has initiated an investigation of illegal imports of ethanol into the United States; the investigation is expected to take about 2 years. Initially, attention will focus on importers who misdeclare that ethanol will be used for industrial uses (subject to a 3-percent *ad valorem* tariff) rather than for fuel use (subject to an additional tariff of $0.60 per gallon).

Customs also will seek information on imported ethanol that has been blended with other products to qualify for a lower tariff or simply reported to be a different product. Customs will investigate if ethanol is being transshipped illegally through a Caribbean country to qualify for a tariff exemption under the Caribbean Basin Initiative program. Customs also will examine whether ethanol produced from petroleum or natural gas may be entering the fuel market and receiving ethanol subsidies intended only for fermentation ethanol.

In addition, if sufficient evidence is found, Customs will expand the investigation to include potential violations of Bureau of Alcohol, Tobacco, and Firearms regulations concerning payment of taxes on beverage alcohol. Several fuel ethanol producers also have beverage alcohol licenses and Customs suspects that the $12.50-tax per proof gallon is not being paid on some beverage ethanol.

Ethanol-Toluene Blends

On September 12, 1984, the Customs Service issued a ruling permitting imports of ethanol blends containing at least 7-percent toluene without payment of the $0.60-per-gallon duty charged on unblended ethanol imports. On August 2, 1985, Customs reversed this ruling, thereby subjecting ethanol-toluene blends to the duty. The reversal included a provision under which blend imports contracted for in reliance on the earlier ruling could enter until November 2, 1985, without payment of the duty.

The Court of International Trade (CIT) subseqently determined, in response to a suit brought by several domestic ethanol producers, that shipments allowed to enter without payment under the grandfather clause had not been contracted for in reliance on the September 1984 ruling letter and companies that imported the contested shipments during the grandfather period were required to pay the $0.60-per-gallon duty.

GSP Treatment of Ethanol Blends

In January 1986, the Customs Service determined that mixtures of ethanol with certain chemicals under certain tariff classifications were eligible for duty-free treatment under the Generalized System of Preferences (GSP). This ruling permitted imports of fuel ethanol, when blended in specific percentages with other chemicals, without payment of the 3-percent *ad valorem* duty and $0.60-per-gallon tariff applicable to fuel ethanol imports.

On March 31, 1986, a Presidential proclamation withdrew the duty-free benefits of the GSP from chemical mixtures containing ethanol (5). As far as can be determined, very little, if any, ethanol was imported under the GSP during the period ethanol blends were included.

Ethanol can be made from any feedstock containing starch or fermentable sugar. Corn has been the preferred feedstock in the United States because it is readily available, stores well (facilitating year-round ethanol production), and has been relatively inexpensive compared with other potential feedstocks. Table 8 compares U.S. feedstock costs. Cellulosic materials, such as wood and crop residues, may be used as a feedstock, but low alcohol conversion rates and higher unit production costs have prevented their commercial use.2/

The byproducts of ethanol produced from corn are carbon dioxide and distillers dried grains (DDG) or distillers dried grains with solubles (DDGS) from plants that use dry-milling technology and corn gluten feed (CGF), corn gluten meal (CGM), corn oil, and carbon dioxide from plants that use wet-milling technology. DDG, DDGS, CGF, and CGM are marketed as high-protein animal feeds. Carbon dioxide may be marketed for food or industrial uses.

Brazil, the world's largest producer of fuel ethanol, produces about 2.5 billion gallons of ethanol per year from sugarcane. Sugarcane is not a cost-competitive ethanol feedstock in the United States because Government price supports hold the domestic price of sugar well above world levels. Very little information is available about the costs of producing ethanol in Brazil, and dollar values change with changes in inflation and currency values. However, we estimate that the cost of producing ethanol in Brazil was about $0.85-$1 per gallon in 1985. Ethanol produced from sugarcane in Brazil has a significant cost advantage over ethanol produced from corn in the United States.

There are significant economies of scale in ethanol production (table 9). Some ethanol plants may be able to reduce their costs by using used plant and equipment and inexpensive feedstocks (such as off-grade corn), and by selling the grain byproduct without drying it. On average, however, it appears that production costs in corn dry-milling plants producing 10 million gallons per year or less exceed $2 per gallon, whereas costs in plants producing 40 million gallons are about $1.67 per gallon, including a normal profit (15-percent return on equity).

For this analysis, ethanol production was assumed to be the principal product produced in the ethanol plants. Byproduct values were deducted from total costs to arrive at estimates of the cost of producing ethanol.3/

Information on costs of producing ethanol in corn wet-milling plants is proprietary and not readily available. However, based upon available information, we estimated that ethanol production costs, including a

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2/ A recent report by the Solar Energy Research Institute estimates that the potential exists for ethanol produced in a 50-million-gallon-per-year plant using wood as the feedstock to cost $1.56-$1.80 per gallon (including a normal profit) depending on technology used. These estimates could err by ± 30 percent (35).

3/ It may be theoretically desirable to assume that feeds produced in an ethanol plant are coproducts and to allocate costs accordingly among the products. Such a refinement would not be expected to alter the cost estimates enough to affect the conclusions drawn in this study.

Table 8—Feedstock costs for ethanol production in the United States, 1985

Item	Units	Corn	Grain sorghum	Wheat	Potatoes for processing	Sugar beets	Sugarcane	Sweet potatoes
Feedstock price 1/	Dol./bu	2/2.49	3/2.40	3/3.16	4/3.93	5/37.90	5/28.60	6/9.94
Ethanol yield	Gal./bu	2.50	2.50	2.50	7/1.40	8/20.30	8/17.00	7/2.35
Feedstock cost per gallon of ethanol	Dol.	1.00	.86	1.26	2.81	1.87	1.68	4.23
Byproduct yield	Lbs/bu	16.80	16.80	20.70	9/	10/264	9/	9/
Byproduct price	Dol./ton	94.00	94.00	94.00	9/	121	9/	9/
Byproduct credit per gallon of ethanol	Dol.	11/-.32 12/-.46	-.32	-.39	9/	-.79	9/	9/
Net feedstock cost per gallon of ethanol	Dol.	11/ .68 12/ .54	.54	.87	2.81	1.08	1.68	4.23

1/ No transportation costs included.
2/ Average price received by farmers for calendar year 1985.
3/ Average price received by farmers for 1984 crop year (October 1984-September 1985 for grain sorghum; June 1984-May 1985 for wheat).
4/ Dollars per hundredweight for the October 1984-August 1985 period.
5/ Dollars per ton for the 1984 crop year.
6/ Dollars per hundredweight, season average price 1985-86.
7/ Gallons per 100 pounds.
8/ Gallons per ton.
9/ Byproduct is of limited monetary value.
10/ Pounds per ton of sugar beets.
11/ Dry milling.
12/ Wet milling.

Sources: Economic Research Service and National Agricultural Statistics Service, U.S. Department of Agriculture; and (21).

Table 9--Cost per gallon of ethanol, corn dry-milling plants, 1985

Cost	Ethanol plant size (million gallons per year) 10	20	40	60	80	100	120
	Dollars per gallon						
Energy	0.26	0.26	0.26	0.26	0.26	0.26	0.26
Other direct	.17	.11	.08	.08	.06	.06	.06
Indirect	.25	.18	.13	.13	.11	.11	.11
Capital recovery	.71	.58	.49	.45	.42	.40	.38
Feedstock 1/	1.02	1.02	1.02	1.02	1.02	1.02	1.02
Byproduct credit 2/	-.31	-.31	-.31	-.31	-.31	-.31	-.31
Total	2.10	1.84	1.67	1.63	1.56	1.54	1.52

1/ Assumes a corn price of $2.35 per bushel plus $0.20 transportation costs and a yield of 2.5 gallons of ethanol per bushel.

2/ Assumes distillers dried grain price of $92 per ton and 16.8 pounds of distillers dried grain per bushel of corn.

Sources: (3), (7), table 8, and appendix table 3.

normal profit, were about $1.54 per gallon in 1985, or about $0.15 below costs in efficient dry-milling plants. More detailed production cost data are presented in appendix tables 3 and 4.

Wet-milling plants achieve lower costs because: part of the wet-milling plants' facilities and, therefore, costs (e.g., storage, grinding, laboratories, waste disposal, management, marketing) are shared with high-fructose corn syrup (HFCS) production; ethanol can be produced using excess HFCS capacity during the winter when demand for HFCS is low; and the feed byproducts of wet milling have a higher market value than the feed byproducts from dry-milling plants.

Approximately 60 percent of the ethanol produced in the United States in 1985 was from wet-milling plants. We estimate that the weighted average cost of producing ethanol is about $1.60 per gallon ($67.20 per barrel).4/

Fuel ethanol sold for about $0.90 per gallon in July 1986. This price does not reflect its free market value because gasoline blenders qualify for Federal and State ethanol subsidies. After deducting the value of the subsidies ($0.60 per gallon for the Federal subsidy and some $0.30-$0.40 average for State subsidies), the net cost of ethanol to blenders is about zero. This indicates that ethanol producers could not survive without the subsidies, and suggests that most will need even larger subsidies to stay in business unless petroleum prices increase

4/ Prices of oil and gasoline are quoted for 42-gallon barrels. Ethanol values are stated in barrel units here simply as a reference to aid in relating ethanol prices and costs to oil and gasoline prices.

sharply. Net of applicable subsidies, ethanol is selling for about $0.30 per gallon less than the wholesale price of gasoline.

Future Ethanol Production Costs

Future costs of ethanol production will be determined largely by feedstock costs, possible improvements in technology, and changes in the general costs of doing business. We have not attempted to forecast technological changes in ethanol production that would reduce future costs, but discuss the sensitivity of costs to technological changes that might occur. Changes in operating costs were estimated using forecasts from the Department of Energy and estimates from the USDA Economic Research Service's Food and Agricultural Policy Simulator Model (FAPSIM).5/ Macroeconomic assumptions and some of the exogenous variables used in the FAPSIM model are shown in appendix tables 1 and 2.

In the model, growth in agricultural productivity is assumed to continue at the pace of the past decade. Corn yields are projected to rise from 118 bushels per acre in 1985 to 126.5 in 1995. Food and industrial uses of corn and food uses of wheat are determined endogenously in the model and expand largely as a result of population growth throughout the period. Wheat exports are assumed to increase 110 percent over the 1985-95 period, while corn exports are assumed to increase about 85 percent.

A baseline and two scenarios were postulated to reflect different growth rates in the ethanol industry (table 10). The scenarios should not be viewed as either predictions or goals. We felt that these two scenarios provide an adequate basis for evaluating the sensitivity of impacts of possible changes in ethanol production.

Baseline--1 Billion Gallons of Fuel Ethanol in 1995

In the baseline, which reflects ERS's current estimate, ethanol production is assumed to grow steadily from 595 million gallons in crop year 1985 to 1.028 billion gallons in crop year 1995.6/ This growth rate assumes a continuation of existing subsidies, including extension of the Federal subsidy, which is

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5/ FAPSIM is an annual econometric model containing 360 endogenous and 265 exogenous variables that is used to estimate equilibrium livestock and crop prices and production, farm production expenses, cash receipts, net farm income, Government deficiency and reserve storage payments, and consumer food price indices (17). Many of the assumptions used in FAPSIM are used only for comparison purposes; they are not official USDA estimates. Energy costs were forecast using DOE's projections for steam coal prices since most ethanol plants use coal. Other costs were estimated using implicit GNP deflator values from the FAPSIM model. Capital costs were assumed to be fixed once a plant was built. As new capacity was assumed to be built, the appropriate current capital cost was applied and then held fixed for that amount of capacity through 1995. Per-unit capital cost for any given year equals the weighted average for the various age plants assumed to be in operation that year.

6/ Unless otherwise noted, all data and analyses in the remainder of this report are for crop years, usually October-September for the corn crop.

Table 10--Ethanol production scenarios for analysis of impacts on agriculture and Government program costs, crop years

Crop year	Total: Ethanol	Total: Corn needed for ethanol	Wet milling: Ethanol	Wet milling: Corn	Wet milling coproducts: Oil	Wet milling coproducts: Corn gluten--Feed	Wet milling coproducts: Corn gluten--Meal	Dry milling: Ethanol	Dry milling: Corn	Dry milling: Distillers dried grain
	Million gallons	Million bushels	Million gallons	Million bushels	Million pounds	Million pounds	Million pounds	Million gallons	Million bushels	Million pounds
Baseline:										
1985	595	238	345	138	221	1,725	345	250	100	1,680
1986	638	255	363	145	232	1,815	363	275	110	1,848
1987	700	280	375	150	240	1,875	375	325	130	2,184
1988	748	299	388	155	248	1,938	388	360	144	2,419
1989	810	324	412	165	264	2,062	412	398	159	2,675
1990	845	338	425	170	272	2,125	425	420	168	2,822
1991	883	353	438	175	280	2,188	438	445	178	2,990
1992	920	368	450	180	288	2,250	450	470	188	3,158
1993	958	383	463	185	296	2,313	463	495	198	3,326
1994	990	396	475	190	304	2,375	475	515	206	3,461
1995	1,028	411	488	195	312	2,438	488	540	216	3,629
Scenario 1--totals:										
1985	595	238	345	138	221	1,725	345	250	100	1,680
1986	700	280	400	160	256	2,000	400	300	120	2,016
1987	789	316	425	170	272	2,125	425	364	146	2,453
1988	941	376	475	190	304	2,375	475	466	186	3,125
1989	1,092	437	525	210	336	2,625	525	567	227	3,814
1990	1,243	497	575	230	368	2,875	575	668	267	4,486
1991	1,395	558	600	240	384	3,000	600	795	318	5,342
1992	1,546	618	600	240	384	3,000	600	946	378	6,350
1993	1,697	679	600	240	384	3,000	600	1,097	439	7,375
1994	1,849	740	600	240	384	3,000	600	1,249	500	8,400
1995	2,000	800	600	240	384	3,000	600	1,400	560	9,408
Scenario 1--increments to baseline:										
1985	0	0	0	0	0	0	0	0	0	0
1986	62	25	37	15	24	185	37	25	10	168
1987	89	36	50	20	32	250	50	39	16	269
1988	193	77	87	35	56	438	88	106	42	706
1989	282	113	113	45	72	563	113	169	68	1,142
1990	398	159	150	60	96	750	150	248	99	1,663
1991	512	205	162	65	104	813	163	350	140	2,352
1992	626	250	150	60	96	750	150	476	190	3,192
1993	739	296	137	55	88	688	138	602	241	4,049
1994	859	344	125	50	80	625	125	734	294	4,939
1995	972	389	112	45	72	563	113	860	344	5,779

Continued --

Table 10--Ethanol production scenarios for analysis of impacts on agriculture and Government program costs, crop years--continued

Crop year	Total: Ethanol	Total: Corn needed for ethanol	Wet milling: Ethanol	Wet milling: Corn	Wet milling: Coproducts: Oil	Wet milling: Coproducts: Corn gluten--Feed	Wet milling: Coproducts: Corn gluten--Meal	Dry milling: Ethanol	Dry milling: Corn	Dry milling: Distillers dried grain
	Million gallons	Million bushels	Million gallons	Million bushels	------Million pounds-------			Million gallons	Million bushels	Million pounds
Scenario 2--totals:										
1985	595	238	345	138	221	1,725	345	250	100	1,680
1986	500	200	325	130	208	1,625	325	175	70	1,176
1987	425	170	300	120	192	1,500	300	125	50	840
1988	400	160	300	120	192	1,500	300	100	40	672
1989	375	150	300	120	192	1,500	300	75	30	504
1990	350	140	300	120	192	1,500	300	50	20	336
1991	325	130	300	120	192	1,500	300	25	10	168
1992	80	32	75	30	48	375	75	5	2	34
1993	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0
Scenario 2--increments to baseline:										
1985	0	0	0	0	0	0	0	0	0	0
1986	-138	-55	-38	-15	-24	-190	-38	-100	-40	-672
1987	-275	-110	-75	-30	-48	-375	-75	-200	-80	-1,344
1988	-348	-139	-88	-35	-56	-438	-88	-260	-104	-1,747
1989	-435	-174	-112	-45	-72	-562	-112	-323	-129	-2,171
1990	-495	-198	-125	-50	-80	-625	-125	-370	-148	-2,486
1991	-558	-223	-138	-55	-88	-688	-138	-420	-168	-2,822
1992	-840	-336	-375	-150	-240	-1,875	-375	-465	-186	-3,124
1993	-958	-383	-463	-185	-296	-2,313	-463	-495	-198	-3,326
1994	-990	-396	-475	-190	-304	-2,375	-475	-515	-206	-3,461
1995	-1,028	-411	-488	-195	-312	-2,438	-488	-540	-216	-3,629

Assumptions: 2.5 gal. of ethanol per bushel of corn. Wet milling yields 12.5 lbs. of corn gluten feed, 2.5 lbs. of corn gluten meal, and 1.6 lb. of oil per bushel of corn. Dry milling yields 16.8 lbs. of distillers dried grain per bushel of corn.

scheduled to expire in 1992. About 65 percent of the growth is assumed to be in corn dry milling.

Scenario 1--2 Billion Gallons of Fuel Ethanol in 1995

Scenario 1 projects rapid growth of the U.S. fuel ethanol industry. This scenario assumes that Federal and State fuel ethanol subsidies will be maintained or increased through 1995, that gasoline prices will soon rise again to 1985 levels or higher, that ethanol will make a significant contribution to boosting octane ratings when lead is banned from gasoline, that EPA will make a favorable ruling on volatility limits permitting the sale of methanol-ethanol-gasoline blends under the duPont waiver to the Clean Air Act, that EPA will not reduce evaporative-emissions standards for all gasoline, or some combination of these or other factors. Scenario 1 represents the most optimistic growth rate one might practically expect in the absence of a major oil supply disruption.

Annual fuel ethanol production by corn wet millers is assumed to increase by 255 million gallons, while the output of dry millers would increase by 1.15 billion gallons. Several industry representatives have indicated that growth in ethanol production by wet millers is determined more by changes in demand for high-fructose corn syrup than demand for ethanol. This is because it is not economically feasible to build ethanol production capacity unless a plant's overhead costs can be shared with HFCS production. The HFCS market has grown rapidly recently as soft drink bottlers substituted HFCS for sugar due to high sugar prices caused by the U.S. sugar price support program. However, once HFCS makes significant inroads in the sugar market, growth in the HFCS market will level off (unless production of crystalline sugar from corn becomes practical for large-scale production), thereby limiting increases in ethanol production by corn wet millers.7/

Scenario 2--Disappearance of the Fuel Ethanol Industry by 1995

Scenario 2 reflects ethanol's prospects if gasoline prices remain low, State ethanol tax subsidies are phased out, and the Federal gasoline excise tax exemption for gasohol is not extended beyond 1992. Production by corn dry millers is phased down steadily through 1992 while corn wet millers are assumed to continue producing at about the same level until the Federal tax exemption terminates at the end of 1992. The industry could lose sales even more rapidly if EPA reduces gasoline evaporative emissions standards.

Assumptions About Byproduct Feeds

Ethanol feed byproducts compete with soybean meal and other feeds. When ethanol production increases, the larger supply reduces the price of the feed byproducts and soybean meal. In this analysis, the value of byproduct feeds was assumed to equal approximately the price of soybean meal on a protein-equivalent basis. Prices of distillers dried grain, corn gluten feed, and corn gluten meal were assumed to equal 61 percent, 50 percent, and 100 percent of soybean meal prices, respectively.8/

7/ Relatively small quantities of crystalline sugar now are being produced from corn. Production is projected to increase in the next few years although higher costs and technical factors are expected to prevent this new product from competing fully with cane and beet sugar in the immediate future.

8/ In the FAPSIM analysis, the economic impacts of additional supplies of ethanol feed byproducts were estimated by determining the amount of soybean meal the byproducts would replace on a protein-equivalent basis and adding that amount to the supply of soybean meal. Corn oil was assumed to replace soybean oil on a one-to-one-basis.

Total DDG production in the United States in 1985 (including byproducts of HFCS and other products) was 1.1 million tons, about 88 percent of which was from fuel ethanol production. DDG production has doubled since 1981 but still represents less than 5 percent of the total supply of high-protein feeds.

Total U.S. production of CGF and CGM in 1985 was about 5.6 million short tons or about 22 percent of the total supply of high-protein feeds. Some 3.8 million tons were exported, almost all to the European Economic Community (EEC) at an average price of $126.60 per ton.

The EEC gluten market was opened to U.S. sellers by a trade concession granted in the midsixties, which was bound in the General Agreement on Tariffs and Trade. The agreement permitted unlimited, duty-free access. The EEC periodically threatens to withdraw the concession and restrict gluten feed imports. The assumption was made that the changes in ethanol production considered here will not cause a change in EEC policies regarding gluten feeds.

Cost Estimates

Before estimating the effect changes in ethanol production would have on future Government outlays, one must estimate how large a subsidy ethanol producers would need. These subsidy needs, in turn, depend on future ethanol production costs and gasoline prices. Estimates of future ethanol production costs are summarized in table 11 and appendix tables 3 and 4.9/ These cost estimates include a normal return on equity. They also assume that new plant and equipment are acquired and that market rates are paid on borrowed funds. Costs for dry-milling plants in the baseline case are projected to increase from $1.67 per gallon ($70 per barrel) in 1985 to $2.03 ($85 per barrel) in 1995.10/ Cost increases occur due to higher general costs of doing business, higher capital costs for new plants, and, after 1989, higher corn prices. Ethanol production costs are higher in scenario 1 than in the baseline, as increased production bids up corn prices and bids down the price of protein feeds. The cost difference is only $0.02 per gallon in 1988 but rises to $0.07 in 1991 and $0.14 in 1995. Scenario 2 shows that reduced ethanol production in the later years examined reduces costs below baseline levels. Costs are $0.05 lower in 1988 and $0.12 lower in 1995. Costs in scenario 2 are $0.26 per gallon lower than in scenario 1 in 1995. Ethanol production costs drop sharply in 1986 due to lower corn prices. Costs continue to decline through the 1989 crop year and rise rapidly after 1993.

9/ Differences in assumptions used in this analysis would affect the estimates. For example, each $0.10-per-bushel change in corn prices would alter ethanol production costs by about $0.05-$0.07 per gallon, and each 1-percentage-point change in interest rates could alter costs by about $0.03 per gallon. Technological improvements also could be significant. For example, a 10-percent increase in the feedstock-to-ethanol conversion rate, which is plausible, though not easily achieved, would lower feedstock costs about $0.09 per gallon. Significant technological progress already has been made that reduced energy and other operating expenses. An additional 10-percent reduction in operating costs ($0.08-$0.09 per gallon) may be possible within the time period covered by this report.

10/ All economic projections in this report are expressed in nominal dollars.

Table 11--Projected ethanol production costs, crop years

Year	Wet milling			Dry milling			Average for all production		
	Baseline	Scenario 1	Scenario 2	Baseline	Scenario 1	Scenario 2	Baseline	Scenario 1	Scenario 2
	Nominal dollars per gallon								
1985	1.54	1.54	1.54	1.67	1.67	1.67	1.59	1.59	1.59
1986	1.41	1.41	1.40	1.52	1.52	1.51	1.46	1.46	1.44
1987	1.40	1.40	1.38	1.51	1.51	1.48	1.45	1.45	1.41
1988	1.38	1.40	1.36	1.49	1.51	1.44	1.43	1.45	1.38
1989	1.39	1.41	1.35	1.48	1.52	1.43	1.43	1.47	1.37
1990	1.44	1.48	1.40	1.53	1.59	1.48	1.48	1.54	1.41
1991	1.51	1.57	1.47	1.61	1.68	1.55	1.56	1.63	1.48
1992	1.61	1.65	1.54	1.72	1.78	1.63	1.67	1.73	1.55
1993	1.68	1.74	1.63	1.79	1.90	1.72	1.74	1.84	NA
1994	1.78	1.84	1.71	1.90	2.02	1.80	1.84	1.96	NA
1995	1.90	1.97	1.81	2.03	2.17	1.91	1.97	2.11	NA
	Production weights								
1985	0.580	0.580	0.580	0.420	0.420	0.420	NA	NA	NA
1986	.569	.571	.650	.431	.429	.350	NA	NA	NA
1987	.536	.539	.706	.464	.461	.294	NA	NA	NA
1998	.519	.505	.750	.481	.495	.250	NA	NA	NA
1989	.509	.481	.800	.491	.519	.200	NA	NA	NA
1990	.503	.463	.857	.497	.537	.143	NA	NA	NA
1991	.496	.430	.923	.504	.570	.077	NA	NA	NA
1992	.489	.388	.938	.511	.612	.062	NA	NA	NA
1993	.483	.354	NA	.517	.646	NA	NA	NA	NA
1994	.480	.324	NA	.520	.676	NA	NA	NA	NA
1995	.475	.300	NA	.525	.700	NA	NA	NA	NA

NA denotes not applicable.

Sources: Table 10 and appendix tables 3 and 4.

Costs for wet-milling plants are estimated to average $1.54 per gallon ($65 per barrel) in 1985, falling to $1.38 in 1988, and rising to $1.90 ($80 per barrel) in 1995 in the baseline case. Costs in scenario 1 are estimated to be $0.07 per gallon higher than in the base case in 1995, compared with $0.09 per gallon lower in scenario 2. Wet millers are projected to have about a $0.13-per-gallon cost advantage over dry millers in 1995 in the base case, a $0.20 advantage in scenario 1, and a $0.10 cost advantage in scenario 2. Weighted average ethanol production costs for the industry were estimated to be $1.59 per gallon ($67 per barrel) in 1985, rising to $1.97 per gallon ($83 per barrel) in 1995 in the base case and $2.11 ($89 per barrel) in scenario 1.

Future Gasoline Prices

Average wholesale prices for all grades of gasoline were projected using data obtained from the Department of Energy (DOE). DOE's latest oil price projections were published in an April 1986 service report (28). Three oil price cases were reported. One assumed that the average world oil price in 1986 would be $10 per barrel, another assumed $15 per barrel, and the third assumed $20 per barrel. All three projected the same range of prices in 1995. We selected the $15-per-barrel case since that now appears to be the most likely average price for 1986. Two price paths were projected for this case. One, labeled the base case, projected that world oil prices would reach $32 per barrel (in 1985 dollars) by 1995. The other, labeled the low-price case, projected that world oil prices would reach only $24 per barrel by 1995. Refinery and wholesale margins were added to the oil prices to obtain estimates of wholesale gasoline prices through 1995 (table 12).

In the base case, real gasoline prices at wholesale are projected to decline through 1987 and then return to their 1985 level by 1992. In the low-price case, prices (in real terms) are projected to decline through 1988 and not return to the 1985 levels by 1995. In nominal dollars, wholesale gasoline prices are estimated to reach $1.16 per gallon ($49 per barrel) in 1995 in the low case and $1.44 per gallon ($60 per barrel) in the base case.

Potential Future Ethanol Subsidy Demands

The existence of the fuel ethanol industry has been dependent on several forms of Government assistance: Federal and State gasoline excise tax exemptions,11/ blender tax credits, energy investment tax credits, loans and loan guarantees, Government funding for feasibility studies, and tariffs on imported fuel ethanol. Some of these benefits will not be available in the future. The energy investment tax credit expired in 1985, few new loan guarantees will be granted, and Government funding of feasibility studies is rare. State ethanol subsidies are available in only 29 States, averaging (unweighted) about $0.045 per gallon of gasohol ($0.45 per gallon of ethanol), and vary widely among the States ($0.01-$0.16). Heavy reliance on State subsidies is risky for ethanol producers because State legislatures frequently alter the subsidies.

11/ Two States provide a sales tax exemption and two others provide direct producer subsidies in lieu of a gasoline excise tax exemption.

Table 12--Projected wholesale gasoline prices

Year	1984 dollars		Nominal dollars			
	Base case	Low-price case	Base case		Low-price case	
	Calendar year		Calendar year	Crop year	Calendar year	Crop year
	Dollars per gallon 1/					
1985	0.83	0.83	0.83	0.63	0.83	0.63
1986	.55	.55	.56	.56	.56	.55
1987	.52	.52	.56	.59	.55	.57
1988	.54	.51	.60	.68	.58	.63
1989	.61	.55	.71	.82	.64	.72
1990	.70	.61	.86	.97	.75	.83
1991	.78	.66	1.00	1.09	.85	.91
1992	.85	.70	1.12	1.21	.93	.99
1993	.89	.73	1.24	1.32	1.01	1.07
1994	.93	.75	1.35	1.42	1.09	1.14
1995	.95	.76	1.44	1.50	1.16	1.21
1996 2/	NA	NA	1.52	NA	1.23	NA

1/ Assumes that refinery and wholesale margins will remain constant in real dollars, equal to the 1981-85 average ($0.188 per gallon of gasoline).
2/ Estimated by extrapolation. NA denotes not estimated.

Sources: (28, p. 9, and 29).

Several unpredictable factors will determine how large a Government subsidy ethanol producers would require if they are to continue competing in the gasoline market. Principal among these are future gasoline prices and ethanol production costs, discussed above, and the value of ethanol as an octane additive in relation to other octane-enhancing chemicals.

Since ethanol has a higher octane rating than gasoline, some representatives of the ethanol industry argue that, on a per-gallon basis, ethanol should be priced above the wholesale price of gasoline. Historically, the two products have sold at about the same price after deducting applicable Federal and State ethanol subsidies. At this time, however, gasoline companies are discounting ethanol some $0.20-$0.25 per gallon below the wholesale price of gasoline after deducting the applicable direct tax subsidies. This indicates that while ethanol has a higher octane rating than gasoline, other octane-boosting alternatives also are available at a lower cost. Since many of these octane alternatives are petroleum based and their prices fell with world oil prices earlier this year, it was estimated that their prices will continue to be low, forcing ethanol to be priced at a discount for many years. In this analysis, the discount is assumed to be $0.20 per gallon in 1986 dollars during the 1986-95 crop year period.

Estimates of the amount of subsidy needed by ethanol producers if they are to operate at a profit are shown in table 13 for the two gasoline price

Table 13--Differential between projected ethanol costs plus a market discount factor and wholesale gasoline prices, crop years 1/

Crop year	Wet milling			Dry milling		
	Baseline	Scenario 1	Scenario 2	Baseline	Scenario 1	Scenario 2
	Nominal dollars per gallon					
Base case:						
1985	1.01	1.01	1.01	1.14	1.14	1.14
1986	1.06	1.06	1.05	1.17	1.17	1.16
1987	1.03	1.03	1.01	1.14	1.14	1.11
1988	.93	.95	.91	1.04	1.06	.99
1989	.81	.83	.77	.90	.94	.85
1990	.72	.76	.68	.81	.87	.76
1991	.68	.74	.64	.78	.85	.72
1992	.67	.71	.60	.78	.84	.69
1993	.64	.70	.59	.75	.86	.68
1994	.65	.71	.58	.77	.89	.67
1995	.70	.77	.61	.83	.97	.71
Low-price case:						
1985	1.01	1.01	1.01	1.14	1.14	1.14
1986	1.07	1.07	1.06	1.18	1.18	1.17
1987	1.05	1.05	1.03	1.16	1.16	1.13
1988	.98	1.00	.96	1.09	1.11	1.04
1989	.91	.93	.87	1.00	1.04	.95
1990	.86	.90	.82	.95	1.01	.90
1991	.86	.92	.82	.96	1.03	.90
1992	.89	.93	.82	1.00	1.06	.91
1993	.89	.95	.84	1.00	1.11	.93
1994	.93	.99	.86	1.05	1.17	.95
1995	.99	1.06	.90	1.12	1.26	1.00

1/ Assumes that ethanol will be priced $0.20 per gallon below the wholesale price of gasoline (in 1986 dollars) beginning in the middle of the 1985 crop year. The values in this table are estimates of the amount of subsidy that would be needed to enable ethanol producers to compete in the gasoline market and receive a normal profit.

Sources: Calculated from tables 11 and 12.

scenarios.12/ We have attempted to estimate how large a subsidy ethanol producers would need to compete in the gasoline market, not whether subsidies should be provided.

A substantial subsidy would be needed to make ethanol production economically viable through 1995. Corn wet millers would require subsidies of $0.58-$1.06 per gallon ($24-$45 per barrel) to cover all costs and earn a normal profit if gasoline prices follow the base case. Corn dry millers would need larger subsidies, ranging from $0.75 to $1.17 per gallon if gasoline prices follow the base case. Subsidy requirements would be greater, $0.82-$1.07 per gallon ($34-$45 per barrel) in the low gasoline price case. In the low gasoline price case, dry millers' subsidy needs rise to $0.90-$1.18 per gallon ($38-$50 per barrel). Subsidy requirements are higher in scenario 1 than in scenario 2.

In the base gasoline price case, the subsidies alone needed by ethanol producers using wet and dry corn-milling technology will exceed the entire cost of gasoline through the 1988-89 crop years. In the low gasoline price case, subsidies will exceed the cost of gasoline until 1989-92 in most situations. In scenario 1, the subsidy needs of dry millers are estimated to exceed the cost of gasoline through 1995.

The survival of ethanol producers has always depended heavily on Federal and State subsidies. While subsidy needs of dry millers are estimated to decline after the 1985 crop year by 11-21 percent in the low gasoline price case and 26-41 percent in the base gasoline case, they will still require a minimum of $0.75 per gallon ($31.50 per barrel) in the base case, $0.84 per gallon ($35 per barrel) in scenario 1, and $0.67 per gallon ($28 per barrel) in scenario 2. Wet corn millers also are expected to need, at a minimum, an extension of the present Federal subsidy through 1995 if they are to earn a normal profit. In most years, wet millers would need $0.10-$0.20 per gallon more than provided by the present Federal subsidy in order to receive a normal return on investors' equity.

12/ There are no statistical measures that would help quantify the probability and magnitude of possible errors in these estimates. In light of past experience, we feel that there is a good chance these estimates will be revised. The most sensitive factors influencing the accuracy of the projections are feedstock costs and gasoline prices; so, we have specifically provided alternative values of these factors (different feedstock costs are embodied in the scenarios). Care should be taken when using estimates of average subsidy requirements because operating costs of specific existing ethanol producers vary widely depending on the technology they use, the age of their plants, and so forth. Since dry millers have higher production costs, subsidies that would meet their needs would permit wet millers to reap economic profits. Similarly, since older ethanol plants would have lower ownership costs than new ones, the average subsidy requirements shown here are unlikely to be large enough to encourage new entrants in later years. On the other hand, these estimates make no allowance for technological improvements that could reduce ethanol production costs (see footnote 9 above).

Unless gasoline prices rise substantially faster than presently forecast by DOE or unless Federal ethanol subsidies are extended beyond 1992, this analysis suggests that little or no ethanol production will occur after December 1992.13/

EFFECTS OF INCREASED ETHANOL PRODUCTION ON AGRICULTURE AND CONSUMERS

The FAPSIM analysis conducted by ERS shows that changes in ethanol production affect both farmers and consumers. The impacts discussed in this section result from a change in the demand for corn used to produce the ethanol. Any factors that would cause the same changes in demand for corn, e.g., burning corn in coal furnaces, would have similar effects on agriculture and consumers. Although this report examines the effects of ethanol production, one should not conclude that ethanol production is necessarily a more efficient way to increase demand for corn or to reduce excess supplies than other options.14/ Appendix table 5 summarizes major impacts.

Crop and Livestock Production

Increased ethanol production would expand corn acreage due to increased use of corn as an alcohol feedstock. Acreage of other feed grains would expand as they substitute for corn in the domestic feed market and sorghum substitutes for corn in the export market. Total acreage would increase only slightly; most of the supply adjustments would occur through crop switching rather than acreage expansion. Soybean production would decline due to lower soybean prices caused by increased production of corn high-protein byproduct feeds.

A 1-billion-gallon-per-year increase in ethanol production would increase corn acreage by about 800,000 acres (about 1.1 percent). The impact of a 1-billion-gallon decrease in ethanol production would be smaller, reducing corn acreage by about 600,000 acres or less (about 0.8 percent).

Production of pork and grain-fed beef would decline slightly with additional ethanol production due to increased costs of grains. Production of nonfed beef would rise due to lower relative production costs. Production of poultry would rise due to lower feed costs for high-protein feed.

Crop Exports

With increased ethanol production, corn exports would fall due to rising corn prices. Sorghum would substitute for corn in the export market. Exports of soybeans, soybean meal, and corn byproduct feeds would rise due to lower product prices.

13/ Revenue would exceed variable costs for some plants. These plants would have an incentive to continue producing (at a loss) if there is no good alternative use for their facilities and if their creditors do not force foreclosure.

14/ For example, the report does not compare the effects of increased ethanol production with the effects of acreage reduction programs for agriculture because options for an acreage reduction program have not been developed.

Domestic Feed Market

If ethanol production increases, use of corn in the domestic feed market would fall due to higher corn prices. Other feed grains and wheat would replace corn in livestock feed rations since their prices would increase proportionately less than the price of corn. Use of soybean meal and corn byproduct feeds would rise as their prices fall relative to grain prices. Total expenditures for purchased feeds would fall. A reduction in ethanol production would have the opposite effects.

Prices

Corn prices would be affected by changes in demand for corn as an ethanol feedstock.15/ In scenario 1, each 100-million-bushel increase in demand for corn as an ethanol feedstock increases corn prices by $0.02-$0.04 per bushel on average. In scenario 2, each 100-million-bushel decrease in corn demand reduces corn prices by $0.02-$0.03 per bushel. Prices of other grains also move in the same direction due to changes in their use in the domestic feed market and the export market.

Additional ethanol production causes soybean and soybean meal prices to decline as ethanol byproducts enter the feed market, reducing the domestic demand for soybean meal. Each 100-million-bushel increase (decrease) in ethanol-induced demand for corn reduces (increases) soybean prices by about $0.04 per bushel. Soybean meal prices are estimated to decline by $0.12-$0.15 per hundredweight for each 100-million-bushel increase in ethanol-induced demand for corn. Conversely, each 100-million-bushel decrease in corn demand would increase soybean meal prices by $0.11-$0.17 per hundredweight.

Increased ethanol production increases consumer food prices, due to higher farm prices for grain and animal products. The overall effect is small in percentage terms, but relatively large when related to the additional amount of ethanol produced. On average, annual consumer food expenditures increase about $2.29 per additional gallon of ethanol produced in scenario 1. Conversely, consumer expenditures are estimated to decline by about $1.99 per gallon if ethanol production declines as in scenario 2.

Increased ethanol production is not expected to influence gasoline prices. Gasoline prices are essentially controlled by worldwide supply and demand conditions in the petroleum and other hydrocarbon energy markets. Ethanol production is so small that producers are price takers. The changes in ethanol production examined in this report represent less than 1 percent of U.S. gasoline consumption. Ethanol supplies potentially could affect retail gasoline prices in some local areas but there is no basis for estimating the magnitude of any possible effects.

15/ When ethanol production increases the demand for corn, corn prices rise, reducing the quantity of corn demanded for other uses. Production of corn increases the following year, thereby moderating subsequent price increases. As a result of these price changes, net changes in corn use in any one year do not necessarily equal changes in the amount required for ethanol production.

Farm Receipts and Net Farm Income

Additional ethanol production increases farmers' receipts for both crops and livestock (even though receipts of soybean producers are reduced). Total expenses also rise. Overall, increased ethanol production is estimated to boost corn prices and cut feed costs enough to increase net farm income in most years. On average, net farm income increases $0.58 for each additional gallon of ethanol produced in scenario 1 and declines by $0.44 for each 1-gallon reduction in ethanol production in scenario 2.

If boosting net farm income is an important motive for encouraging ethanol production, it is appropriate to compare the increase in farm income to the cost of subsidizing ethanol production. As will be shown below, consumers and taxpayers together would find it less expensive to buy straight gasoline and directly pay $0.58 to corn growers for each additional gallon of ethanol that would have been produced in scenario 1.

EFFECTS OF INCREASED ETHANOL PRODUCTION ON GOVERNMENT FARM PROGRAM COSTS

Ethanol production affects three types of farm program costs: direct cash support payments to farmers (deficiency and dairy payments); storage payments for farmer-owned grain reserves (FOR) and Commodity Credit Corporation (CCC) stocks; and outlays for commodity loans. The last category differs from the first two since commodity loans are recoverable if and when the loans are repaid or forfeited grain is sold.

Increased ethanol production in scenario 1 stimulates demand for corn and raises corn prices. As a result, fewer farmers would participate in Government price support programs, lowering program costs. Deficiency payments would fall. Less grain would be placed in farmer-owned reserves and fewer farmers would forfeit on their CCC loans. Government storage payments for FOR and CCC grain would fall. Government loan outlays also would fall. The opposite effects would occur if ethanol production were to decline as in scenario 2.

Direct Program Costs

The FAPSIM analysis suggests that savings due to reductions in deficiency payments and commodity storage costs in scenario 1 would amount to a total of $3.3 billion over the 1986-94 period due to higher corn prices and smaller inventories held in farmer-owned reserves. Savings vary widely over time, ranging from $74 million in 1986 to $955 million in 1994 (table 14). Over 90 percent of the savings are in the corn program. About 90 percent of the savings are due to reduced deficiency payments resulting from higher corn prices.

Ethanol production declines in scenario 2, causing an increase in direct program costs. As in scenario 1, most of the effects are in the corn program (90 percent) and changes in deficiency payments account for about 80 percent of the changes.

Table 14--Estimated effects of changes in ethanol production on agricultural program costs, crop years

Item	1986	1987	1988	1989	1990	1991	1992	1993	1994
	Million dollars								
DIRECT PROGRAM COSTS 1/									
Scenario 1:									
Corn	-65.2	-114.7	-229.4	-292.0	-345.3	-102.1	-343.8	-666.9	-879.5
Cumulative total	-65.2	-179.9	-409.3	-701.3	-1,046.6	-1,148.7	-1,492.5	-2,159.4	-3,038.9
All commodities	-74.2	-126.5	-250.8	-322.4	-379.7	-89.1	-370.2	-744.7	-954.8
Cumulative total	-74.2	-200.7	-451.5	-773.9	-1,153.6	-1,242.7	-1,612.9	-2,357.6	-3,312.4
Scenario 2:									
Corn	138.6	275.7	412.9	461.4	445.7	181.9	167.9	1,076.2	198.1
Cumulative total	138.6	414.3	827.2	1,288.6	1,734.3	1,916.2	2,084.1	3,160.3	3,358.4
All commodities	160.0	300.0	451.4	505.3	499.3	210.6	229.5	1,115.2	265.9
Cumulative total	160.0	460.0	911.4	1,416.7	1,916.0	2,126.6	2,356.1	3,471.3	3,737.2
LOAN TRANSACTIONS 2/									
Scenario 1 change in FOR stocks:									
All grain	-27.0	-19.4	-52.8	-55.5	-72.3	-85.8	-91.3	38.7	-34.4
Cumulative total	-27.0	-46.4	-99.2	-154.7	-227.0	-312.8	-404.1	-365.4	-399.8
Scenario 2 change in FOR and CCC stocks:									
All grain	72.0	103.3	106.0	80.8	85.5	91.1	135.0	298.5	113.8
Cumulative total	72.0	175.3	281.3	362.1	447.6	538.7	673.7	972.2	1,086.0

1/ Deficiency and dairy payments and commodity storage costs.
2/ FOR = Farmer-owned reserve and CCC = Commodity Credit Corporation.

Source: Economic Research Service.

The program effects become more meaningful when they are related to the amount of additional ethanol produced (table 15). The savings per gallon of additional ethanol in scenario 1 average $0.88 over the 1986-94 period. In scenario 2, program costs increase an average of $0.99 per gallon not produced.

Indirect Program Costs

Some indirect savings could be realized with increased ethanol production because fewer commodity loans would be made. Initial outlays for commodity loans would decline by nearly $400 million over the 1986-94 period in scenario 1. The reduction per additional gallon of ethanol averages $0.11 over the period (table 15). Actual net savings would be smaller if the Government subsequently recovers some of its initial loan outlays through loan repayments and sale of forfeited grain.

Initial outlays for commodity loans increase by about $1.1 billion due to reduced ethanol production in scenario 2. The increases average $0.29 per gallon of ethanol not produced during the 9-year period examined. As in scenario 1, the net effect on agricultural program costs depends on how much of the initial outlay is later recovered through loan repayment and sale of forfeited grain. This factor is discussed in more detail below.

SUMMARY OF ECONOMIC IMPACTS ON FARMERS, CONSUMERS, AND GOVERNMENT PROGRAMS

Information is not available to estimate some of the impacts that increased ethanol production would have on our economy, such as increased economic activity in rural communities, negative income effects on the petroleum industry, and potential improvements in air quality. Since the value of resources used to produce a gallon of ethanol far exceeds the value of resources used to produce a gallon of gasoline, production of fuel ethanol represents an inefficient use of our Nation's resources. This means that if all economic costs and benefits of increased ethanol production could be tallied, the costs would exceed the gains unless it could be shown that external costs and benefits or future gains not reflected in present market conditions would have a material impact.

The projected benefits of ethanol production shown in this report assume that the additional ethanol is produced from U.S. corn. However, U.S. ethanol subsidies also accrue to foreign ethanol producers unless importers pay the full $0.60-per-gallon tariff that applies to fuel ethanol. Countries in the Caribbean Economic Recovery Act program are exempt from the U.S. ethanol import tariff. And, legal devices have been found whereby large quantities of ethanol have entered the United States without paying the fuel ethanol tariff. Continuation of such exceptions would reduce any gains or increase losses projected for the United States in this analysis.

Estimated impacts of increased ethanol production on Federal outlays, farm income, and consumer food expenditures are summarized in table 16.

Table 15--Estimated per-gallon effects of changes in ethanol production on agricultural program costs, crop years

Item	1986	1987	1988	1989	1990	1991	1992	1993	1994	Mean
	Dollars per incremental gallon									
DIRECT PROGRAM COSTS 1/										
Scenario 1:										
Corn	-1.05	-1.29	-1.19	-1.04	-.87	-.20	-.55	-.90	-1.02	-.81
All commodities	-1.20	-1.42	-1.30	-1.14	-.95	-.17	-.59	-1.01	-1.11	-.88
Scenario 2:										
Corn	1.00	1.00	1.19	1.06	.90	.33	.20	1.12	.20	.89
All commodities	1.16	1.09	1.30	1.16	1.01	.38	.27	1.16	.27	.99
INITIAL CHANGE IN LOAN TRANSACTIONS										
Scenario 1:										
Corn	-.33	-.17	-.23	-.17	-.16	-.15	-.13	.05	0	-.08
All grain	-.44	-.22	-.27	-.20	-.18	-.17	-.15	.05	-.04	-.11
Scenario 2:										
Corn	.32	.32	.20	.16	.15	.14	.14	.28	.10	.24
All grain	.52	.38	.30	.19	.17	.16	.16	.31	.11	.29

1/ Weighted average for 1986-94.

Sources: Tables 10 and 14.

Table 16--Estimated change in Federal outlays, net farm income, and food expenditures due to changes in ethanol production, crop years

Item	1986	1987	1988	1989	1990	1991	1992	1993	1994	Mean 1/
	Dollars per incremental gallon of ethanol									
BASE GASOLINE PRICE CASE										
Net change in Government costs with the following CCC loan recovery rates: 2/										
Scenario 1--										
No recovery	-0.47	-0.50	-0.51	-0.40	-0.26	0.51	0.10	-0.10	-0.26	-0.10
50% recovery	-.25	-.39	-.38	-.30	-.17	.59	.18	-.13	-.24	-.04
75% recovery	-.14	-.33	-.31	-.25	-.12	.64	.21	-.14	-.23	-.02
100% recovery	-.03	-.28	-.24	-.20	-.08	.68	.25	-.15	-.22	.01
Scenario 2--										
No recovery	.52	.36	.61	.50	.42	-.18	-.26	.79	-.29	.19
50% recovery	.26	.17	.46	.40	.34	-.26	-.34	.64	-.35	.08
75% recovery	.13	.07	.39	.36	.29	-.30	-.38	.56	-.37	.03
100% recovery	0	-.02	.31	.31	.25	-.34	-.42	.48	-.40	-.02
LOW GASOLINE PRICE CASE										
Net change in Government costs with the following CCC loan recovery rates: 2/										
Scenario 1--										
No recovery	-.46	-.48	-.46	-.30	-.12	.69	.32	.15	.02	.10
50% recovery	-.24	-.37	-.32	-.20	-.03	.78	.40	.12	.04	.16
75% recovery	-.13	-.31	-.26	-.15	.02	.82	.43	.11	.05	.18
100% recovery	-.02	-.26	-.19	-.10	.06	.86	.47	.10	.06	.21
Scenario 2--										
No recovery	.51	.34	.56	.40	.28	-.36	-.48	.54	-.57	0
50% recovery	.25	.15	.41	.31	.20	-.44	-.56	.39	-.63	-.10
75% recovery	.12	.05	.34	.26	.15	-.48	-.60	.31	-.65	-.16
100% recovery	-.01	-.04	.26	.21	.11	-.52	-.64	.23	-.68	-.21
Change in net farm income:										
Scenario 1	.19	-.33	-.07	.14	.26	1.35	.76	.57	.55	.58
Scenario 2	-.18	.17	.13	-.16	-.34	-1.39	-.98	-.04	-.42	-.44
Change in consumer food expenditures:										
Scenario 1	2.20	2.10	1.31	1.58	2.02	2.68	2.31	2.35	2.58	2.29
Scenario 2	-1.98	-1.36	-1.46	-1.76	-2.06	-3.23	-2.42	-1.71	-1.61	-1.99

1/ Weighted average for 1986-94.
2/ Savings in agricultural program costs less revenue lost due to subsidies needed to make up the difference between projected gasoline prices and ethanol production costs.
Sources: Tables 10, 13, 15, and appendix table 5.

Government Costs

The existing Federal subsidy of \$0.60 per gallon of ethanol would be insufficient to sustain the ethanol industry through 1995.16/ The total subsidies required (by Federal or State governments) to keep the ethanol industry competitive in the gasoline market exceed potential savings in direct agricultural program costs (deficiency, dairy, and storage payments). On this basis, one would have to conclude that additional ethanol production does not benefit the Government in terms of reducing costs.

However, potential indirect savings are possible in the agricultural commodity loan program since additional ethanol production would reduce the amount of loans outstanding. If the Government recovered all of its initial loan outlays, no net savings on commodity loan activities would be possible; but that is unlikely. It would be very difficult to estimate what future recovery rates will be. Therefore, we have elected to show the effects of alternative recovery rates.

If, at the extreme, none of the initial loan outlays are later recovered through loan repayments and sale of forfeited grain, the additional ethanol produced in scenario 1 would reduce the Government's cost of commodity loans by \$0.11 per gallon. Conversely, the decrease in ethanol production shown in scenario 2 would add an average of \$0.29 per gallon to commodity loan program costs.

Table 16 shows the estimated net effects of changes in ethanol production on total Government costs for different loan recovery rates. In the base gasoline price case, additional ethanol produced in scenario 1 would reduce total Government costs by \$0.10 per additional gallon assuming zero recovery of initial commodity loan outlays and would cost the Government \$0.01 per gallon if the loan recoveries reached 100 percent. In the low gasoline price case, additional ethanol production would increase total Government outlays by \$0.10-\$0.21 per additional gallon produced during the 1986-94 crop year period.

In scenario 2, reductions in ethanol production increase net Government costs by up to \$0.19 per gallon in the base gasoline price case. If loan recovery rates approach 100 percent, the reductions in ethanol production would lower total Government costs. In the low price case, reduced ethanol production would cut Government costs regardless of the loan recovery rate.

In total, increases or decreases in ethanol production are estimated to have little net effect on Government program costs. Any savings in agricultural program costs would be offset by larger ethanol subsidy costs. Assumptions about recovery rates on agricultural commodity loans do affect the analysis, but the effects are relatively small.

Farmers

The effect of ethanol production on farm income is quite clear: Ethanol production raises net farm income. The additional gallons postulated in

16/ Ethanol subsidies for corn dry millers were assumed to define the industry's subsidy demands since there have been no proposals to provide different subsidies for wet and dry millers.

scenario 1 would add $2.2 billion to net farm income over the 1986-94 period, or an average of $0.58 per additional gallon. Conversely, cuts in ethanol production in scenario 2 are estimated to lower net farm income by $2.2 billion, or an average of $0.44 per gallon. Soybean producers are hurt by additional ethanol production, but the benefits that accrue to corn and livestock producers more than offset the adverse effects on soybean producers.

Consumers

The largest per gallon impact of changes in ethanol production is on consumers. Over the 1986-94 period, the additional ethanol produced in scenario 1 is estimated to raise consumer food expenditures by $8.6 billion, or an average of $2.29 per additional gallon. Benefits to consumers of reducing ethanol production in scenario 2 total $10 billion over the 1986-94 period, or $1.99 per gallon not produced.

Net Effects

The combined effects of changes in ethanol production on Government costs, farmers, and consumers are summarized in table 17. Regardless of commodity loan recovery rates, the combined effect of increasing ethanol production is negative and the effect of reducing ethanol production is positive.

The net loss resulting from additional ethanol production in scenario 1 amounts to $6.1-$6.5 billion over the 1986-94 period, or an average of $1.61-$1.72 per gallon in the base gasoline price case and $6.8-$7.2 billion ($1.81-$1.92 per gallon) in the low gasoline price case.

In scenario 2, reductions in ethanol production would result in net savings of $6.8-$7.9 billion, or $1.35-$1.57 per gallon not produced in the base gasoline price case and $7.8-$8.9 billion, or $1.54-$1.76 per gallon not produced in the low gasoline price case.

While additional ethanol production would benefit some farmers and offers an opportunity to reduce some Government program costs, these gains must be paid for by large subsidies to ethanol producers and higher consumer food prices. This analysis suggests that ethanol production is a very costly proposition in the United States. Ethanol production has little effect on total Government costs. Its major benefit is higher net farm income. But increases in consumer food expenditures caused by additional ethanol production far exceed the increases in farm income. Consumers would be much better off if they burned straight gasoline in their automobiles and paid a direct cash subsidy to farmers in the amount that net farm income would be increased by ethanol production.

ETHANOL'S PROSPECTS THROUGH 1995

The fuel ethanol industry is not likely to survive the next decade without large Federal and State subsidies. The price of gasoline is not expected to again reach the high level achieved in 1980 until well after 1995 (28). Therefore, a subsidy in excess of the $0.60 per gallon of ethanol provided by the Federal excise tax exemption will be necessary for most existing ethanol plants to continue operating. Without additional subsidies, growth in the ethanol industry is unlikely.

Table 17--Estimated net gains due to changes in ethanol production, crop years 1/

Item	1986	1987	1988	1989	1990	1991	1992	1993	1994	Mean 2/
	Dollars per incremental gallon of ethanol									
BASE GASOLINE PRICE CASE										
Net gains with the following CCC loan recovery rates:										
Scenario 1--										
No recovery	-1.54	-1.93	-0.87	-1.04	-1.50	-1.84	-1.65	-1.68	-1.77	-1.61
50% recovery	-1.76	-2.04	-1.01	-1.14	-1.59	-1.93	-1.73	-1.66	-1.79	-1.67
75% recovery	-1.87	-2.10	-1.07	-1.19	-1.64	-1.97	-1.76	-1.64	-1.80	-1.69
100% recovery	-1.98	-2.15	-1.14	-1.24	-1.68	-2.01	-1.80	-1.63	-1.81	-1.72
Scenario 2--										
No recovery	1.28	1.17	.98	1.10	1.30	2.02	1.70	.88	1.48	1.35
50% recovery	1.54	1.36	1.13	1.20	1.39	2.10	1.78	1.04	1.54	1.46
75% recovery	1.67	1.46	1.20	1.24	1.43	2.14	1.82	1.11	1.56	1.52
100% recovery	1.80	1.55	1.28	1.29	1.47	2.18	1.86	1.19	1.59	1.57
LOW GASOLINE PRICE CASE										
Net gains with the following CCC loan recovery rates:										
Scenario 1--										
No recovery	-1.55	-1.95	-.92	-1.14	-1.64	-2.02	-1.87	-1.93	-2.05	-1.81
50% recovery	-1.77	-2.06	-1.06	-1.24	-1.73	-2.11	-1.95	-1.91	-2.07	-1.87
75% recovery	-1.88	-2.12	-1.12	-1.29	-1.78	-2.15	-1.98	-1.89	-2.08	-1.89
100% recovery	-1.99	-2.17	-1.19	-1.34	-1.82	-2.19	-2.02	-1.88	-2.09	-1.92
Scenario 2--										
No recovery	1.29	1.19	1.03	1.20	1.44	2.20	1.92	1.13	1.76	1.54
50% recovery	1.55	1.38	1.18	1.30	1.53	2.28	2.00	1.29	1.82	1.65
75% recovery	1.68	1.48	1.26	1.34	1.57	2.32	2.04	1.36	1.84	1.70
100% recovery	1.81	1.57	1.33	1.39	1.61	2.36	2.08	1.44	1.87	1.76

1/ Sum of savings in Government program costs and increases in net farm income less increases in consumer food expenditures.

2/ Weighted average for 1986-94.

Sources: Tables 10, 13, and 16.

Some factors could improve the U.S. ethanol industry's competitive position somewhat, but expectations of achieving economic viability without Federal or State subsidies is unrealistic during the time period analyzed in this report. The positive factors include: declines in agricultural commodity feedstock prices, technological improvements in ethanol production including more efficient conversion of cellulosic materials, development of a food market for distillers dried grains, elimination of lead in gasoline, and approval of a Clean Air Act waiver for methanol-gasoline blends that use ethanol as a cosolvent.

Factors that could eliminate the U.S. ethanol industry include: continued low gasoline prices, large imports of lower cost ethanol, expiration and elimination of Federal and State subsidies, higher feedstock prices, and stricter terms for ethanol plant financing.

Lower Feedstock Costs

Corn is the principal feedstock for producing ethanol because it is abundant, easy to convert, and the least expensive feedstock available in the United States. Considerable research efforts by Federal and State institutions have been devoted to reducing feedstock costs. Some varieties of corn are being developed that have higher yields of fermentable starch, permitting increased output of ethanol per bushel. Possible gains in output over the next 10 years may be as much as 5 percent. We might expect feedstocks to decline in price per gallon of ethanol by 5-10 percent over the period.

Nongrain feedstock costs might decline due to improvement in the technologies that convert cellulosic material such as wood, sugarcane, bagasse, cornstalks, and other agricultural residues and wastes. Research continues on increasing yields of fermentable sugars and on complete fermentation of five-carbon sugars. Total fermentation of five-carbon sugars could make woody biomass competitive with corn as an ethanol feedstock (37). In an effort to reduce ethanol feedstock costs, multiple-use crops are being researched. Such crops include legumes for pasture and soil erosion with a cutting made for conversion into ethanol with the leafy material processed into livestock feed (1).

Many of the newer ethanol plants use molecular sieves to separate water from ethanol at lower energy costs than traditional distillation. Other progress has been made toward reducing distillation costs (by about $0.04 per gallon) with a cornmeal-based water adsorber developed at Purdue University. Further technological breakthroughs yielding savings up to $0.10 per gallon might be possible. However, with the assurance of adequate supplies of energy at lower cost, funding for energy research at USDA, DOE, and most land-grant institutions has been reduced significantly since 1984.

Food Uses of Distillers Dried Grain

DDG is sold exclusively for livestock feed. If sold for human consumption, its value would increase and the cost of ethanol production would decline. Research continues in the development of food uses for the byproduct. The Agriculture and Food Act of 1981 (P.L. 97-98) mandated research into the food use of byproducts, especially their use in food distributed under the P.L. 480 Food for Peace program. The research has examined three dry-milling byproducts:

DDG, DDGS, and corn protein concentrate. DDGS was found to have an unacceptable off-flavor prohibiting its use in food products. The other byproducts, while palatable, were found to be deficient in an amino acid required for children's foods shipped under P.L. 480. Byproducts of wheat and barley conversion to ethanol are palatable but food markets for them have not been developed.

Even when markets are developed, ethanol plants must meet stringent food-grade requirements if they are to market their byproduct for human food. Human food-grade standards include the use of stainless steel vessels and piping throughout the ethanol plant, which would increase capital costs sharply. These additional costs may or may not be recovered in the increased value of the byproduct, depending on its selling price. It appears unlikely, as long as current price relationships continue, that many ethanol producers would choose to produce food-grade byproducts. Some day an economical market may be developed but it is not anticipated in the next decade.

Ethanol Imports

With the drop of energy prices in 1986, Brazil has been unable to economically export ethanol to the United States and pay the import duties. It appears that only limited amounts of ethanol will be imported unless petroleum prices increase sharply as long as current import duties are maintained to offset domestic ethanol subsidies.

Over time, however, Brazil and other sugar-producing nations could export substantial amounts of ethanol to the United States if the U.S. import quota or world demand for sugar continues to decline. Many sugar-producing countries are considering producing ethanol with increasing portions of their crops for domestic and export use. Ethanol may be an attractive option to these countries because few good alternative crops are available to them to replace the sugar crop.

Ethanol produced from natural gas also is imported from countries having surplus natural gas supplies such as Saudi Arabia and Indonesia. Due in large part to the low cost of natural gas in areas where it otherwise must be flared or vented, costs of producing ethanol are much lower than for fermentation ethanol produced in the United States. Ethanol produced from petroleum products does not qualify for the Federal and State excise tax exemptions, but the product is chemically indistinguishable from biomass-based ethanol. The U.S. Customs Service alleges that there appears to be some illegal comingling of these products.

Ethanol imported from Saudi Arabia has been landed in U.S. gulf ports at around $0.70 per gallon including freight. Ethanol imported for industrial uses is not subject to the $0.60-per-gallon tariff on imported fuel ethanol, unless it is to be used as a fuel.

Congress has been recently debating legislation designed to close loopholes through which imported (especially Brazilian) ethanol has reportedly been avoiding the fuel ethanol tariff. Actions that close the loopholes may be in violation of the General Agreement on Tariffs and Trade (GATT). If energy prices increase appreciably and sugar prices remain low, we can expect increased imports of biomass-based ethanol from sugar-producing countries as well as increases in natural gas-based ethanol imports from the Persian Gulf and Southeast Asia. Domestic producers who are unable to compete with cheaper foreign supply can be expected to press Congress for import restrictions should this occur.

Eliminating Lead in Gasoline

In 1967, the Environmental Protection Agency under authority of the Clean Air Act determined that the emissions products of lead-based gasoline additives would significantly impair the performance of emission control systems, including catalytic converters. EPA therefore provided for the general availability by July 1, 1974, of lead-free gasoline of an octane quality suitable for 1975 and subsequent years' vehicles (32). In several stages during the period 1976-82, EPA required that the lead level in leaded gasoline be reduced from more than 2.0 to 1.1 grams per gallon.

On July 1, 1985, the lead level was dropped to 0.5 gram per leaded gallon and on January 1, 1986, the standard was lowered to 0.1 gram per leaded gallon.

Ethanol is an excellent octane enhancer. Adding ethanol to gasoline in a 10-percent blend increases octane by about 3 points. Ethanol producers looked to the removal of lead from gasoline as a growing market for ethanol as an octane enhancer instead of just as a fuel extender.

In 1980, unleaded gasoline accounted for 46.6 percent of total gasoline used. By May 1986, the unleaded portion of the gasoline market had risen to 68 percent (75 billion gallons). During this period, ethanol sales rose from 25 million gallons per year to 750 million gallons. The domestic industry expanded 24-fold and provided 625 million gallons in 1985.

There is considerable uncertainty about how oil companies will increase octane as lead is phased out. In its 1985 assessment of lead phase-down, the EPA assumed that oil companies would choose to increase octane ratings through increased crude oil refining at a cost of about $0.015 per gallon more than regular leaded gasoline. The EPA estimates that the industry's total refining capacity is sufficient to meet octane requirements without using octane-enhancing chemical additives such as ethanol, methanol, MTBE, TBA, and toluene.

Lead phase-down has largely been completed. More than 97 percent of the lead in gasoline has been removed. The average amount of lead in all gasoline has dropped from 3.5 grams to 0.1 gram per gallon. While ethanol demand increased to more than 700 million gallons in 1985, most of the octane "gap" was filled by more severe refining of crude oil and by petrochemical-based additives such as toluene, TBA, and MTBE. Additionally, the market for leaded gasoline has dropped from 42 percent of total gasoline sales to 32 percent between the first 5 months of 1984 and 1986, a drop of 8 billion gallons in 2 years. The remaining leaded-gasoline market is about 34 billion gallons of gasoline. Thus, the lead replacement market has declined by 85 percent from 46.5 billion grams in 1984 to 6.8 billion grams currently. As older vehicles continue to drop out of the automotive fleet at an increasing rate, the demand for leaded gasoline will be greatly reduced.

Volatility

Violation of the National Ambient Air Quality Standard for ozone established by EPA is widespread. Evaporative hydrocarbon emissions contribute significantly to ozone problems. High evaporative emissions result when the volatility (as measured by Reid Vapor Pressure and other indices) of fuels exceeds the levels for which most automobiles were designed.

The major reason for higher volatility is believed to be greater use of butane. As heavier crudes make up a larger portion of refinery feed, more crude is hydro-cracked, producing more butane. Because butane enhances octane, is in greater supply, and is inexpensive, a larger amount is appearing in gasoline.

Alcohol blends are significantly more volatile than alcohol-free gasolines. Evaporative emissions reported for ethanol blends are 5 percent to 220 percent above emissions for straight gasoline. Currently, ethanol can be added to gasoline without any legal requirement for volatility controls, whereas methanol blends generally must meet the same specifications applicable to gasoline.

The increased volatility caused by alcohol can be counteracted by removing butanes and other lighter hydrocarbons from gasoline but some data show that the evaporative emissions could still be significantly greater than straight gasoline. Alcohol is more expensive than the lighter hydrocarbons, so it is likely that refiners would prefer to use the less expensive hydrocarbons rather than alcohol to boost octane ratings (32).

EPA has initiated preliminary proceedings, which may result in more uniform volatility limitations for all fuels, including alcohol blends.

The petroleum industry has suggested that EPA raise volatility standards and require that automotive manufacturers produce vehicles with emissions control equipment capable of handling the fuels available now. The automotive industry has suggested that if EPA would enforce the volatility standards now on the books and grant no waivers for any fuel including ethanol, the existing emissions equipment will be adequate. If EPA tightens its volatility standards, sales of alcohol-blended fuels (both ethanol and methanol) could disappear.

Financial Assistance for Ethanol Plants

Most of the fuel ethanol processing plants have been built with private capital. However, the Federal Government played a significant role in expanding the industry by funding feasibility studies (DOE) and providing direct construction loans (DOE) and loan guarantees (DOE, USDA, SBA).

The Federal financial assistance program has been largely terminated. The lending authority of DOE under the Energy Security Act has been extended several times for completion of financial transactions involving several facilities. The USDA authority in FmHA continues, but few loan guarantees have been issued in recent months. With 8 of the 12 alcohol plants financed by FmHA in various stages of liquidation, the agency is carefully scrutinizing the applications still pending.

While ethanol plants may be built within 18-24 months, many have been slow coming on line and a number have failed to achieve designed capacity. Investors and lenders have lost money on ethanol plants and now require exceptionally strong evidence of the soundness of a venture before committing funds. The recent decline in petroleum prices has resulted in lenders' forcing applicants to reexamine their applications and invest more equity capital before the financing packages are accepted.

Given the expected low level of gasoline prices over the next several years and the high cost of producing ethanol, it is doubtful that the industry will find many investors eager to fund new ethanol plants. The tax reform bill likely to be enacted this year appears to place more restrictions on tax shelters and limited partnerships, instruments utilized extensively in the development of the ethanol industry. The tax reform bill also is likely to eliminate the standard 10-percent investment tax credit presently available to all businesses. Therefore, future financial assistance for new ethanol plants appears limited.

CONCLUSIONS

The ethanol industry is one of several alternative-energy industries that developed as a result of the oil shortages and high oil prices in the seventies and the expectation of continuing sharply higher energy prices. All of these alternative-energy industries are high-cost sources of energy that owe their existence to large subsidies. The subsidies were considered necessary to stimulate rapid growth of the industries when depletion of oil and natural gas reserves seemed imminent. Massive worldwide oil and gas exploratory efforts also were mounted induced by higher petroleum prices, and these proved quite successful. Oil and gas resources were developed in a number of non-OPEC countries. The United States diversified its supply of petroleum with much less coming from the Persian Gulf and high prices induced substitution and conservation. Consequently, oil and gas supplies are now plentiful and prices have fallen dramatically. Corn prices also are falling and reducing the cost of producing fuel ethanol, but not enough for it to be competitive given anticipated oil prices during the period examined. Therefore, large Government subsidies will continue to be needed if ethanol producers are to survive.

People generally recognize that our need for renewable energy will increase again one day. They also recognize that it is very expensive to subsidize the production of such energy until then. Since 1981, Federal policy has emphasized continuation of funding for basic research in renewable-energy technologies, while phasing out support for actual production of renewable energy.

The Synthetic Fuels Corporation was abolished, cutting support for the production of shale oil, coal gasification, and other alternative energy sources. Tax credits for investments in renewable energy, including wind, solar, wood, alcohol, and other biomass energy, were allowed to expire in 1985 and Congress is considering legislation that would abolish tax writeoffs for many individuals who have invested in renewable energy plants.

While the fuel ethanol industry has lost most of its investment incentives (energy investment tax credit, direct Government loans, loan guarantees, and feasibility grants), it continues to enjoy the large Federal and State gasoline excise tax exemptions needed by the plants already built, and protection from cheaper imports. The administration has questioned the merit of continuing with the gasoline excise tax exemption by deleting the subsidy in "The President's Tax Proposals to the Congress for Fairness, Growth, and Simplicity" in 1985. Congress appears to be inclined to retain the exemption since it is included in the tax reform bills recently passed by the House and Senate.

Fuel ethanol industry advocates claim that the fuel ethanol industry is different from other alternative-energy industries because ethanol production boosts farm income and reduces Government costs. Increased ethanol production can reduce some agricultural program costs. However, it also increases ethanol subsidy costs. The net effect on Government costs is relatively small; too small to justify either increasing or decreasing ethanol production.

Ethanol production does increase net farm income somewhat even though soybean producers are harmed. On average, the additional ethanol that would be produced in scenario 1 would increase net farm income by an estimated $2.2 billion over the 1986-94 period, or $0.58 per additional gallon. However, a much larger amount (about $5.1 billion or $1.35 per gallon) would go for energy, chemicals, labor, and overhead costs incurred in converting corn into ethanol. Plus, consumers' food costs would rise by $8.6 billion, or an average of $2.29 for each additional gallon of ethanol produced.

When all economic costs and benefits are tallied, an ethanol subsidy program is not cost effective. The costs are so large that ethanol production cannot be justified on economic grounds even if existing producers could get by with present subsidies. If the principal argument for subsidizing ethanol is to boost farm income, we conclude from this analysis that it would be more economical to burn straight gasoline in our automobiles and pay corn growers a direct subsidy equal to the amount they would receive as a result of ethanol production.

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Appendix table 1--Macroeconomic assumptions used in FAPSIM model, crop years

Variable	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
					Percent change					
Real gross national product	2.6	3.1	2.8	4.0	2.9	3.3	3.1	3.2	3.0	3.1
Real disposable personal income per capita	3.3	2.0	1.8	3.0	1.9	2.4	2.2	2.4	2.2	2.3
Nominal income	6.5	5.9	6.6	7.5	6.9	6.6	6.5	6.8	6.6	6.7
Inflation rate GNP deflator	3.0	3.8	4.8	4.4	4.9	4.1	4.2	4.4	4.4	4.3
Money supply-M_2	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Population	1.0	1.0	1.0	.9	1.0	.9	.9	.8	.8	.8
					Percent					
Unemployment rate	7.2	6.7	6.9	6.1	6.3	6.0	5.9	5.7	5.7	5.5
Interest rate, 3-month T-bills	6.6	6.9	7.4	7.8	8.2	8.0	7.9	7.7	7.8	7.8

Source: Economic Research Service.

Appendix table 2--Exogenous annual growth rates used in FAPSIM, crop years

Variable	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
	Percent change									
Variable costs of production 1/										
Corn	-5.8	-2.3	0.6	1.7	1.9	2.0	2.5	2.5	2.5	2.5
Wheat	-4.4	-1.9	1.3	2.0	2.2	2.1	3.2	2.7	2.7	2.7
Sorghum	-6.4	-2.2	.8	1.5	1.8	1.8	2.5	2.1	2.1	2.1
Barley	-4.4	-1.8	1.4	1.8	2.7	1.4	2.6	2.5	2.5	2.5
Oats	-4.6	-1.5	1.9	2.2	2.5	2.2	3.1	2.5	2.5	2.5
Soybeans	-5.3	-2.1	1.3	1.9	2.1	2.2	2.8	2.9	2.9	2.9
Cotton	-5.6	-2.8	2.3	2.9	3.1	3.4	4.0	3.9	3.9	3.9
Rice	-7.4	-3.1	1.8	2.7	3.1	3.5	4.5	4.2	4.2	4.2
Gas	-8.0	-4.3	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
Fuel	- .6	.3	1.7	1.6	1.7	1.5	1.5	1.6	1.6	1.6
Fertilizer	-6.3	-4.7	- .9	0.	.9	1.9	2.1	3.0	4.1	5.0

1/ Includes seed, fertilizer, lime and gypsum, chemicals, custom operations, fuel, lube and electricity, repairs, irrigation water, management fees, general farm overhead expenses, taxes and insurance, interest, capital (machinery) replacement, land rent, and labor.

Source: Economic Research Service.

Appendix table 3--Projected ethanol production costs for 40-million-gallon-per-year corn dry-milling plant, crop years

Item	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
	Nominal dollars per gallon										
Baseline:											
Energy	0.26	0.27	0.29	0.30	0.32	0.34	0.36	0.38	0.40	0.42	0.44
Other direct	.08	.22	.22	.24	.25	.26	.27	.28	.29	.30	.32
Indirect	.13										
Capital recovery	.49	.49	.50	.50	.51	.51	.52	.53	.53	.54	.55
Feedstock	1.02	.84	.83	.81	.80	.82	.86	.91	.95	1.00	1.08
Byproduct credit	.31	.30	.33	.36	.40	.40	.40	.38	.38	.36	.36
Net feedstock cost	.63	.46	.41	.36	.30	.32	.36	.42	.46	.52	.60
Total	1.67	1.52	1.51	1.49	1.48	1.53	1.61	1.72	1.79	1.90	2.03
Scenario 1:											
Energy, other direct, and indirect	.47	.49	.51	.54	.57	.60	.63	.66	.69	.72	.76
Capital recovery	.49	.49	.50	.51	.52	.53	.55	.56	.58	.66	.61
Feedstock	1.02	.84	.83	.82	.81	.84	.88	.93	.99	1.04	1.13
Byproduct credit	.31	.30	.33	.36	.38	.38	.38	.37	.36	.34	.33
Net feedstock cost	.63	.46	.41	.37	.33	.36	.40	.45	.52	.58	.68
Total	1.67	1.52	1.51	1.51	1.52	1.59	1.68	1.78	1.90	2.02	2.17
Scenario 2:											
Energy, other direct, and indirect	.47	.49	.51	.54	.57	.60	.63	.66	.69	.72	.76
Capital recovery	.49	.49	.49	.49	.49	.49	.49	.49	.49	.49	.49
Feedstock	1.02	.83	.82	.79	.78	.80	.84	.88	.93	.97	1.04
Byproduct credit	.31	.30	.34	.38	.41	.41	.41	.40	.39	.38	.38
Net feedstock cost	.63	.45	.39	.32	.27	.29	.33	.37	.43	.47	.54
Total	1.67	1.51	1.48	1.44	1.43	1.48	1.55	1.63	1.72	1.80	1.91

Notes: Energy costs are increased over time using DOE's forecast of steam coal prices in (27). Other direct and indirect costs were projected using changes in the implicit GNP deflator values used in FAPSIM. Capital recovery costs for existing plants were assumed fixed while capital costs for new plants were increased using GNP deflator values from FAPSIM. Feedstock (corn) price projections and byproduct values also were obtained from ERS's FAPSIM analysis. Feedstock costs include transportation charges of $0.20 per bushel in the 1985 crop year, adjusted over time by the GNP deflator from FAPSIM.

Source: Projections made using data from (7), the Economic Research Service FAPSIM model, and (27).

Appendix table 4--Projected ethanol production costs for corn wet-milling plants, crop years

Item	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
	Nominal dollars per gallon										
Baseline:											
Energy	0.26	0.27	0.29	0.30	0.32	0.34	0.36	0.38	0.40	0.42	0.44
Other direct	.08	.22	.22	.24	.25	.26	.27	.28	.29	.30	.32
Indirect	.13										
Capital recovery	.44	.44	.44	.44	.45	.45	.45	.46	.46	.47	.47
Feedstock	1.02	.84	.83	.81	.80	.82	.86	.91	.95	1.00	1.08
Byproduct credit	.39	.36	.38	.41	.43	.43	.43	.42	.42	.41	.41
Net feedstock cost	.55	.40	.36	.31	.27	.29	.33	.38	.42	.47	.55
Total	1.54	1.41	1.40	1.38	1.39	1.44	1.51	1.61	1.68	1.78	1.90
Scenario 1:											
Energy, other direct, indirect expenses	.47	.49	.51	.54	.57	.60	.63	.66	.69	.72	.76
Capital recovery	.44	.44	.44	.45	.45	.46	.47	.47	.47	.47	.47
Feedstock	1.02	.84	.83	.82	.81	.84	.88	.93	.99	1.04	1.13
Byproduct credit	.39	.36	.38	.41	.42	.42	.41	.41	.41	.39	.39
Net feedstock cost	.55	.40	.36	.32	.29	.32	.37	.41	.47	.53	.62
Total	1.54	1.41	1.40	1.40	1.41	1.48	1.57	1.65	1.74	1.84	1.97
Scenario 2:											
Energy, other direct, indirect expenses	.47	.49	.51	.54	.57	.60	.63	.66	.69	.72	.76
Capital recovery	.44	.44	.44	.44	.44	.44	.44	.44	.44	.44	.44
Feedstock costs	1.02	.83	.82	.79	.78	.80	.84	.88	.93	.97	1.04
Byproduct credit	.39	.36	.39	.41	.44	.44	.44	.44	.43	.42	.43
Net feedstock cost	.55	.39	.34	.29	.24	.26	.30	.33	.39	.43	.49
Total	1.54	1.40	1.38	1.36	1.35	1.40	1.47	1.54	1.63	1.71	1.81

Notes: Energy costs are increased over time using DOE's forecast of steam coal prices in (27). Other direct and indirect costs were projected using ERS's forecast for changes in the implicit GNP deflator. Capital recovery costs for existing plants were assumed fixed while capital costs for new plants were increased using GNP deflator values from FAPSIM. Feedstock (corn) price projections and byproduct values were obtained from ERS's FAPSIM analysis. Feedstock costs include transportation charges of $0.20 per bushel in the 1985 crop year, adjusted over time by the GNP deflator from FAPSIM.

Source: Projections made using data from Appendix table 3, the Economic Research Service FAPSIM model, and (27).

Appendix table 5--Estimated effects of change in ethanol production on agriculture, crop years

Item	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
	Percent change from baseline									
SCENARIO 1										
Planted acres:										
Corn	0	0.2	0.2	0.4	0.5	0.6	0.7	0.7	1.1	1.1
Total, 8 crops 1/	0	.1	0	.1	.1	.1	.1	.1	.2	.2
Exports:										
Corn	-.1	-.3	-.7	-1.0	-2.0	-2.8	-4.0	-6.8	-6.6	-7.6
Soybeans	.1	.1	.3	.3	.4	.5	.7	.9	1.0	1.2
Protein feeds 2/	.6	.7	2.0	2.9	4.6	6.1	8.1	10.0	12.3	15.0
Feed uses:										
Corn	-.3	-.3	-.7	-.9	-1.1	-1.2	-1.3	-1.8	-1.9	-2.0
Protein feeds 2/	.1	.1	.3	.4	.5	.7	.8	.9	.9	.9
Farm prices:										
Corn	.7	.6	1.7	2.0	2.5	2.8	2.8	4.6	4.4	5.1
Soybeans	-.4	-.2	-.7	-.8	-1.3	-1.4	-1.7	-1.8	-1.9	-2.4
CPI, all foods	3/	3/	.1	.1	.2	.3	.3	.3	.4	NA
Total receipts	3/	.1	.1	.2	.3	.6	.5	.7	.9	NA
Total expenses	3/	3/	3/	3/	3/	3/	3/	.1	.1	NA
Net farm income	3/	-.1	4/	.1	.2	1.6	1.1	1.0	1.1	NA

See footnotes at end of table.

Continued--

Appendix table 5--Estimated effects of change in ethanol production on agriculture, crop years--continued

Item	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
	Percent change from baseline									
SCENARIO 2										
Planted acres:										
Corn	0	-0.5	-0.4	-0.8	-0.7	-0.7	-0.7	-1.0	-0.8	-0.8
Total, 8 crops 1	0	-.1	-.1	-.2	-.1	-.1	-.1	-.2	-.1	-.1
Exports:										
Corn	.3	.4	1.1	1.4	2.3	2.9	5.7	4.4	4.8	5.4
Soybeans	-.2	-.3	-.4	-.4	-.5	-.6	-1.0	-1.2	-1.4	-1.5
Protein feeds 2/	-1.6	-2.8	-3.8	-4.7	-5.7	-6.6	-10.3	-11.4	-12.7	-13.6
Feed uses:										
Corn	.6	.8	1.2	1.3	1.3	1.3	1.8	1.5	1.5	1.6
Protein feeds 2/	-.3	-.4	-.6	-.6	-.7	-.8	-1.1	-.9	-1.0	-.9
Farm prices:										
Corn	-1.5	-1.4	-2.7	-2.8	-2.9	-2.9	-4.0	-2.9	-3.2	-3.6
Soybeans	.7	.8	1.1	1.2	1.4	1.4	2.5	2.4	2.9	2.9
CPI, all foods	-.1	-.1	-.1	-.2	-.2	-.3	-.4	-.3	-.3	NA
Total receipts	-.1	-.1	-.2	-.3	-.4	-.8	-.7	-.6	-.5	NA
Total expenses	3/	3/	.1	3/	3/	4/	4/	3/	4/	NA
Net farm income	-.1	.2	.1	-.2	-.4	-2.0	-1.9	-.1	-1.0	NA

1/ Includes corn, wheat, sorghum, barley, oats, soybeans, cotton, and rice.
2/ Soybean meal, DDG, DDGS, CGF, and CGM.
3/ Less than 0.05.
4/ Less than -0.05.

NA denotes not applicable.

Source: Economic Research Service.